modern plastics catalog



1941

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Foreword

Heretofore it has been the practice to have an enlarged, augmented regular monthly issue of MODERN PLASTICS serve as the annual catalog. The industry has outgrown the restrictions and limitations which this procedure imposed. In addition this special issue interfered with the chronological presentation of patents and technical developments upon which our readers rely, as well as interrupting other regular features.

Therefore, this year, for the first time, in order to maintain without interruption the continuity of this schedule, the MODERN PLASTICS CATALOG is being published independent of any regular monthly edition. With the catalog having come to be recognized as the foremost reference, as the authoritative reliable source for information on plastics, this program allows a more complete presentation of plastics advancement.

The preparation of an exhaustive, comprehensive treatise such as the MODERN PLASTICS CATALOG would be impossible without the universal cooperation of the industry. With the progressive technical strides which are being made, with the new equipment that is being developed, with the innovations in processing that are being inaugurated and with the ever new materials which are frequently appearing we must inevitably necessarily rely upon those who are acquainted with them for source material. Without exception we have received wholehearted enthusiasm.

Probably no section of past catalogs has been more frequently referred to than the *Plastics Properties Chart.* It has been seated at innumerable technical conference tables on plastics where a ready reference for the respective properties of the many raw materials was required.

In the 1941 MODERN PLASTICS CATALOG there are published for the first time two additional charts, one on *Solvents* (opposite page 424), the other on *Plasticizers* (opposite page 446). These are analogs of the *Plastics Properties Chart* (opposite page 150) which is again appearing completely revised, where required through improvement or change in the raw material involved.

The information contained in these three charts will, for the first time, be available in one place in assembled ready reference form.

An examination of the superabundance of new editorial content clearly demonstrates and forcibly discloses the tremendous forward strides the industry is making. It is in fact a reliable index of the industry's progress—an impressive testimonial to the research work now being done, to the success of that which has gone before and to the preeminent position plastics occupy among the other industrial raw materials of the nation.

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WM. T. CRUSE, *Editor* C. A. BRESKIN, *Publisher*

Acknowledgment to Contributors

The research necessary, the reporting required, the gathering of the facts, the assembling of the information, the preparation of the manuscripts—these and performing the innumerable other necessary duties incidental to publishing so comprehensive a book as the MODERN PLASTICS CATALOG are in their own right a sizable task.

Without the splendid, enthusiastic generous cooperation of the entire plastics industry, such an undertaking as this would fall short of its objective.

The publisher and staff of the MODERN PLASTICS CATALOG acknowledge their thanks and appreciation to all of whose who so willingly and graciously provided of both their time and material in assisting with the preparation of the data and supplying illustrative material for the publication of this work.

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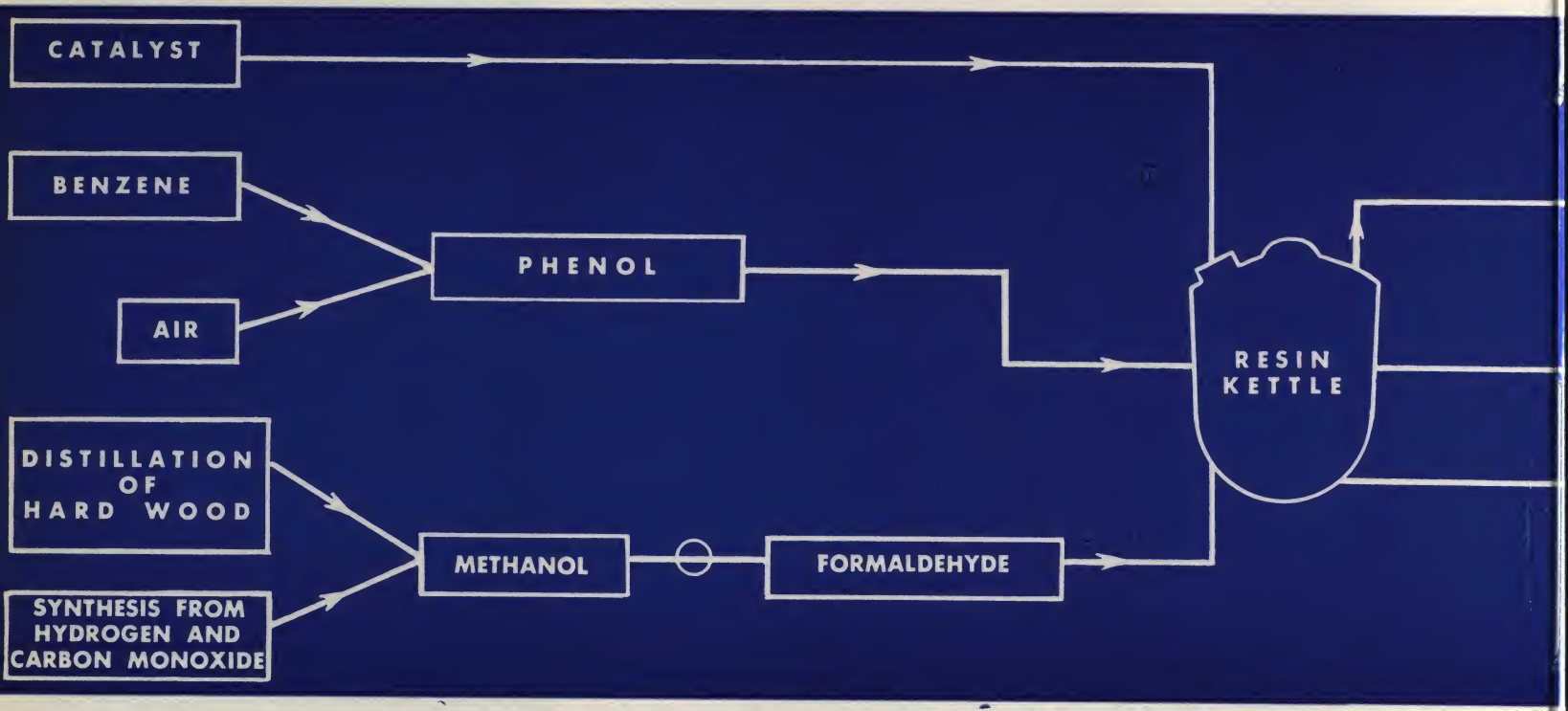
Phenolic Resins



1

1—The basic raw materials for this resin are largely products of chemical synthesis. A typical view of a plant for the catalytic production of phenol from benzene and air shown above

PHOTOS, COURTESY OF BAKELITE CORP. AND DUREZ PLASTICS & CHEMICALS INC.



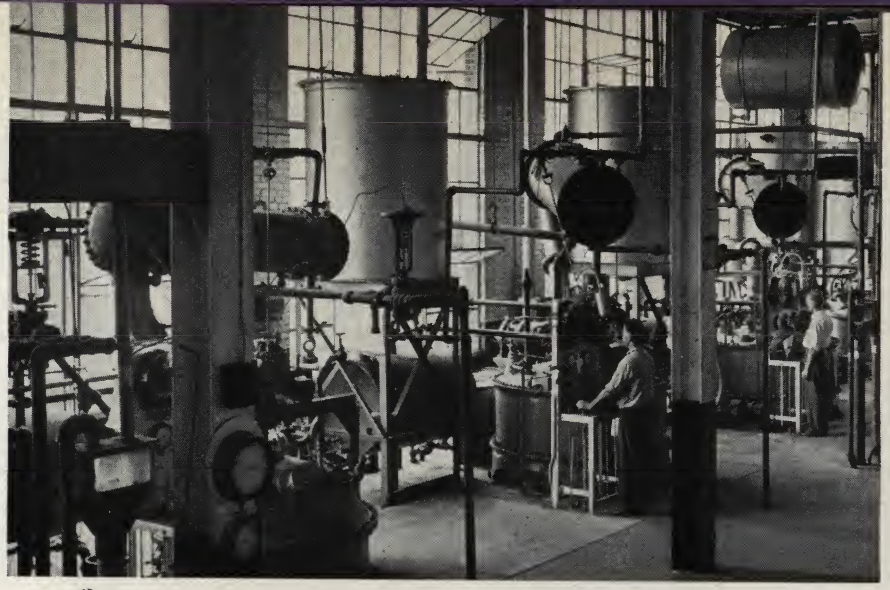
4—On completion of the reaction, the liquid resin is drained into shallow containers for rapid cooling and hardening. The solidified resin is broken up into lumps and then ground to a powder. 5—Wood-flour or other fillers and coloring materials are mixed with the resin on heated compounding rolls and the cure of the resin is advanced to a stage at which it will harden rapidly in the mold

4

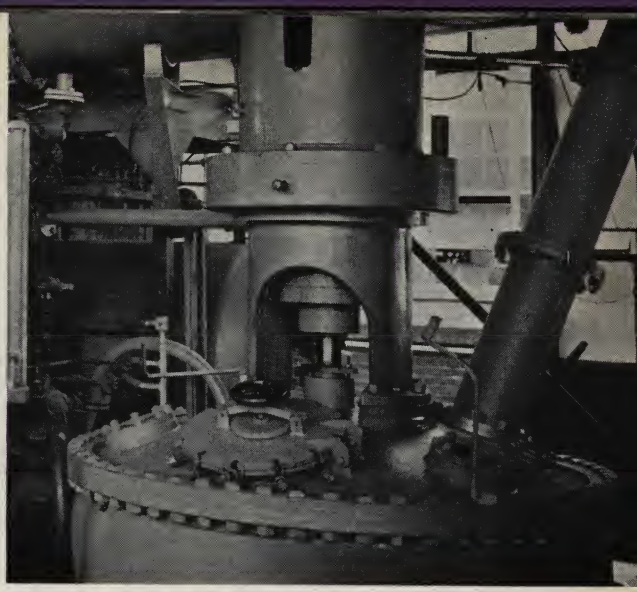


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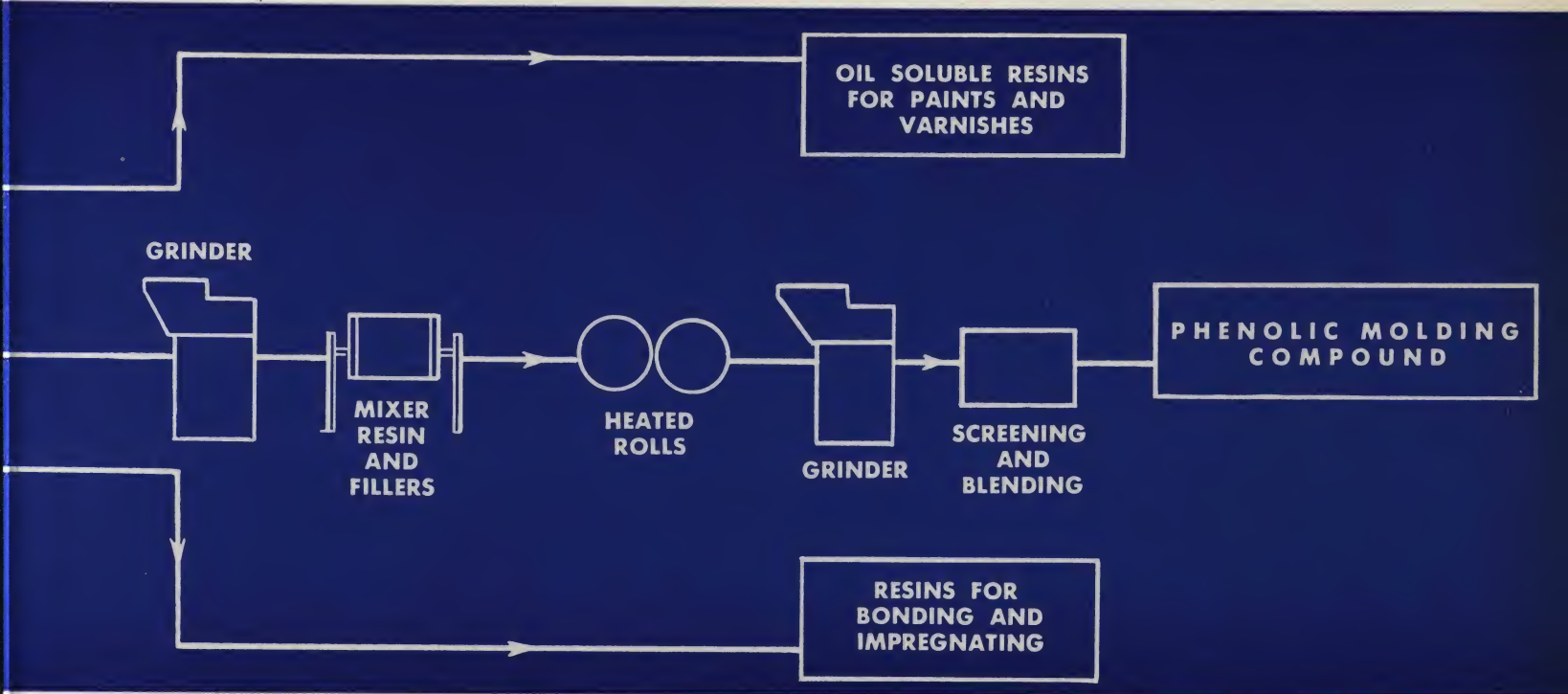


2



3

2—Phenol, formaldehyde, and catalyst are weighed out in the desired proportions and are piped into the resin kettles or into the reservoirs above the kettles. **3**—The phenol and formaldehyde combine in this kettle to form a still fusible resin, having about the consistency of molasses. The agitator is mounted at the center of the vessel. Water formed during the reaction is removed under vacuum

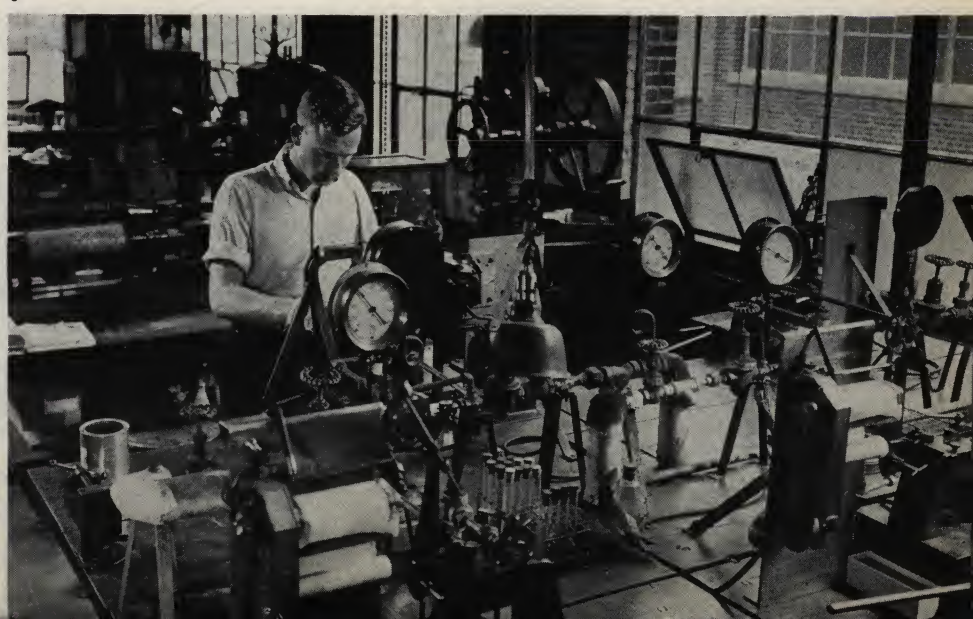


6—The plastic mass is taken from the heated rolls and reground in huge grinding machines. The granular powder is passed over magnetic separators to remove any stray particles of metal. It is then sifted, blended with other batches to ensure a uniform product, and packaged. **7**—At all stages in the process of manufacture, the properties of the molding material are carefully controlled by constant testing against established specifications in the control laboratory

6



7



Cast Resins



1

PHOTOS, COURTESY OF CATALIN CORP. AND MARBLETTE CORP.

1—The phenol formaldehyde and catalyst are placed in these huge kettles for processing into liquid resins suitable for casting. Here dyes are being added to the base resin in the kettle



5—As soon as the molds are filled they are placed in baking ovens where they remain until the resin reaches the necessary hardness. **6**—The molds containing the cured castings are removed from the ovens and the castings ejected with the aid of an air hammer. A technic for making split lead molds for articles with undercuts has recently been developed

5



6





2

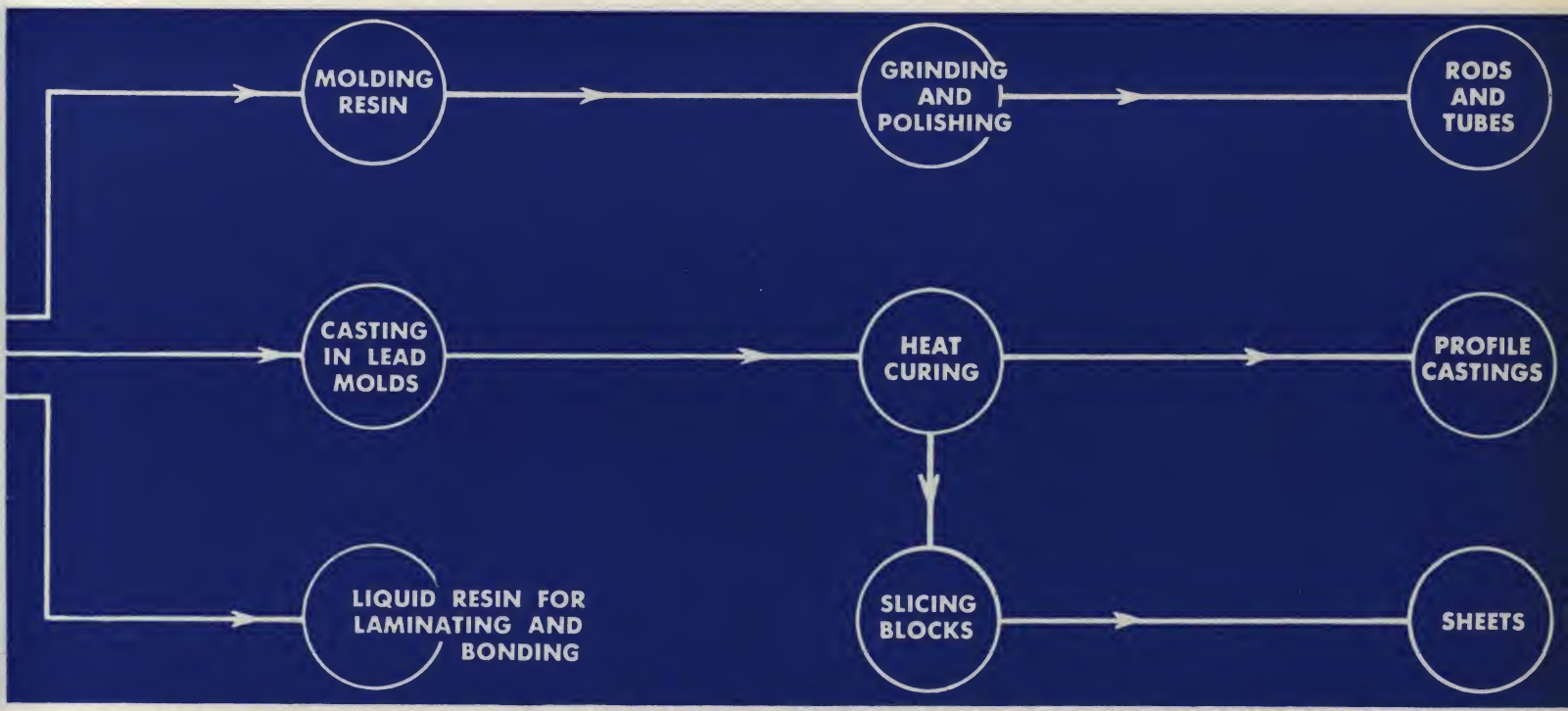


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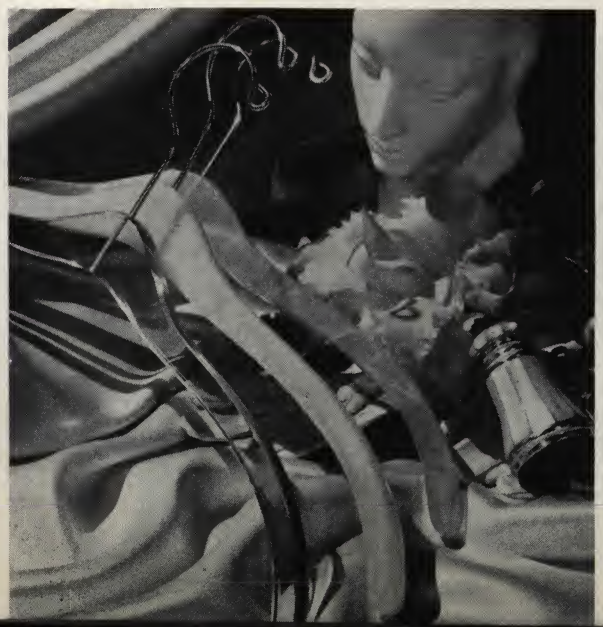
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2—Lead molds for casting rods, tubes and special shapes are formed by dipping master steel patterns into molten lead. Here a dipping arbor or mandrel for producing coat hanger castings is being removed from the molten lead pot with its coating of lead. **3**—The resin is drawn from the reaction kettle while it is still in the liquid stage. **4**—The prepared resin is poured by hand into the lead molds. The molds shown are for coat hangers



7—From the castings these coat hangers are sliced in any desired thickness, polished, drilled for the hook, and ready for milady's wardrobe. **8**—A comprehensive number of widely diversified articles can be fashioned from these ordinary castings. Other stock shapes include handles for cutlery, kitchen equipment and razors, gear shift knobs, automobile fender guides, clock cases, radio housings and lamp base parts

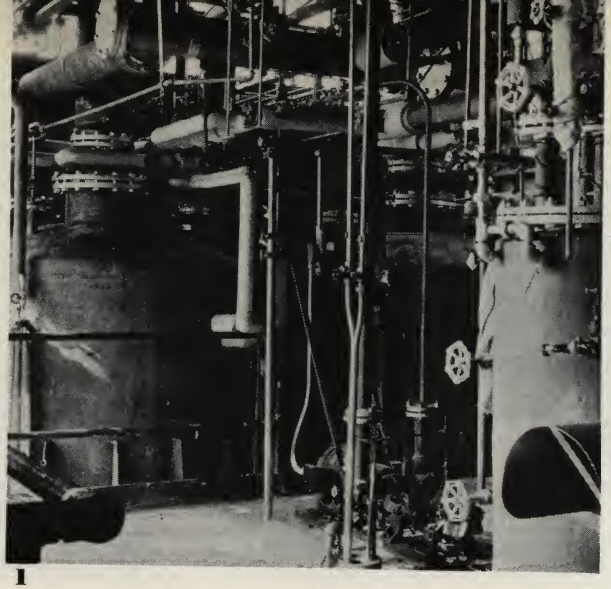
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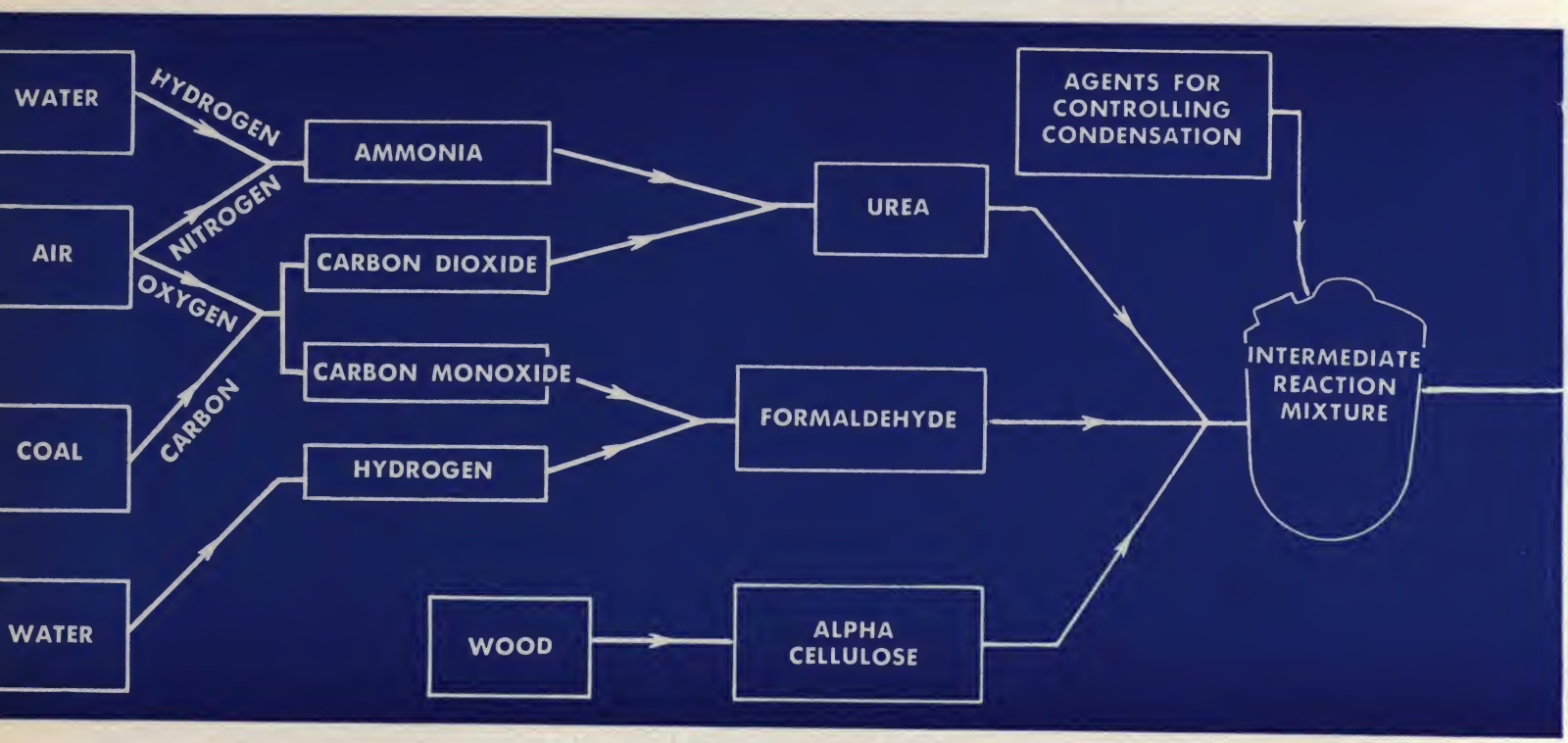
Urea Resins



1

1—Liquid ammonia and liquid carbon dioxide are pumped into a series of pressure vessels in which their combination to form urea takes place

PHOTOS. COURTESY OF DE MATTIA MACHINE & TOOL CO., E. I. DU PONT DE NEMOURS & CO. INC., WATERBURY BUTTON CO.



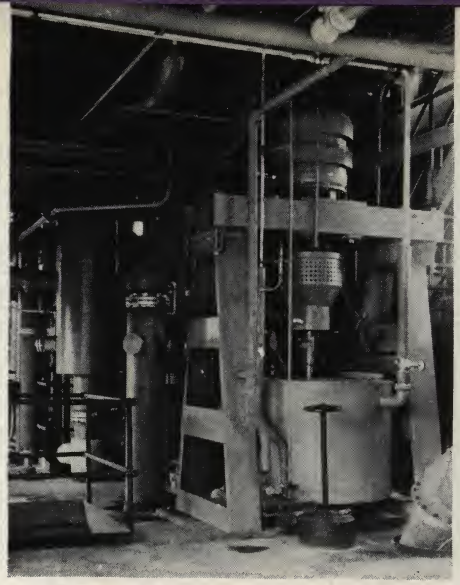
4—The alpha-cellulose filler commonly employed with urea-formaldehyde resin is made by treating wood with chemicals to remove undesirable constituents. The digesters used for this purpose are shown below. 5—The white alpha-cellulose product is formed into sheets which are subsequently shredded to form the filler for introduction into the resin kettle

4

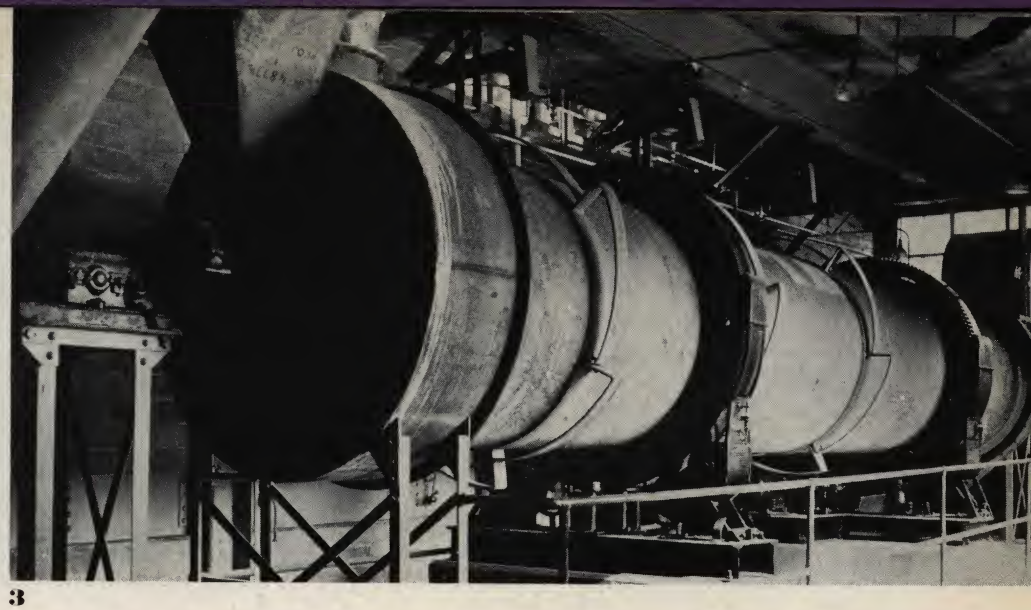


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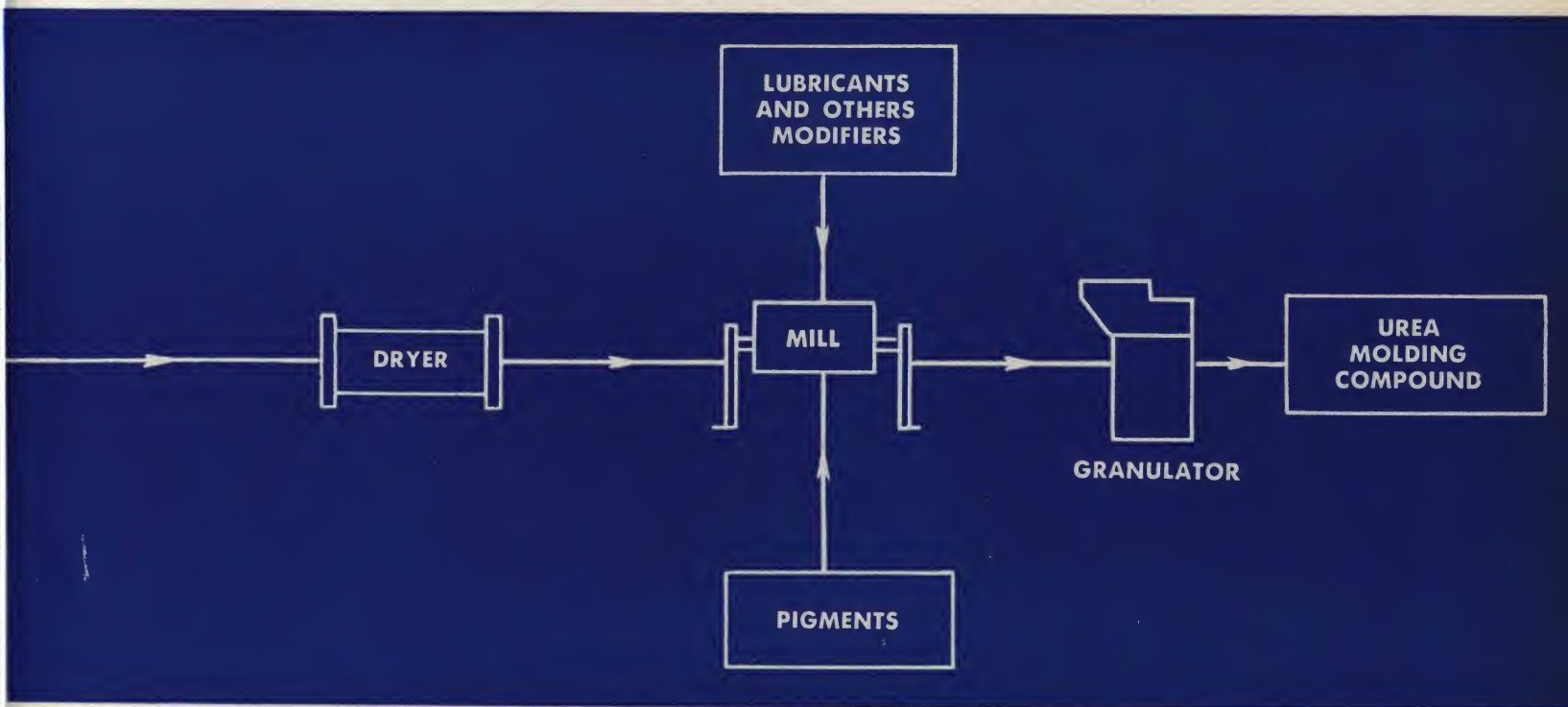


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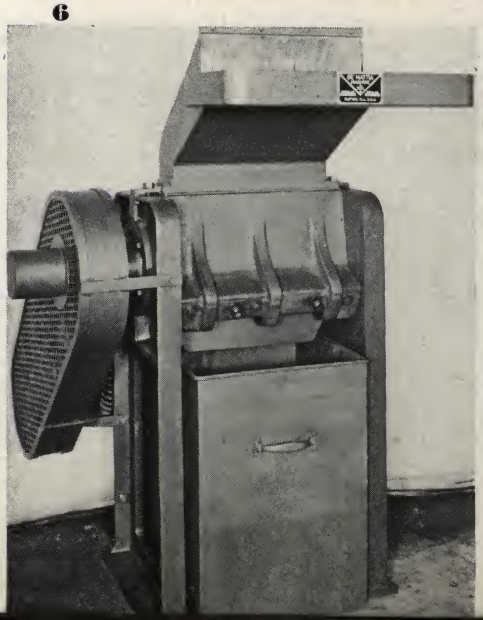
3

2—The solution of urea in water is evaporated and the crystalline urea is recovered by centrifugal separation in the apparatus shown above. **3**—The urea is freed of any remaining water by rotation in a heated dryer. It is mixed with formaldehyde and alpha cellulose in the usual type of reaction vessel and converted to a partially cured resin



6—The mixture from the reaction kettle is partially dried and combined with pigments, dyes, lubricants and curing agents in suitable mixing equipment. The dried composition is put through a granulator to obtain the proper particle size for convenient handling in preforming and molding. **7**—The powder is loaded into cartons and barrels for shipment to molding plants

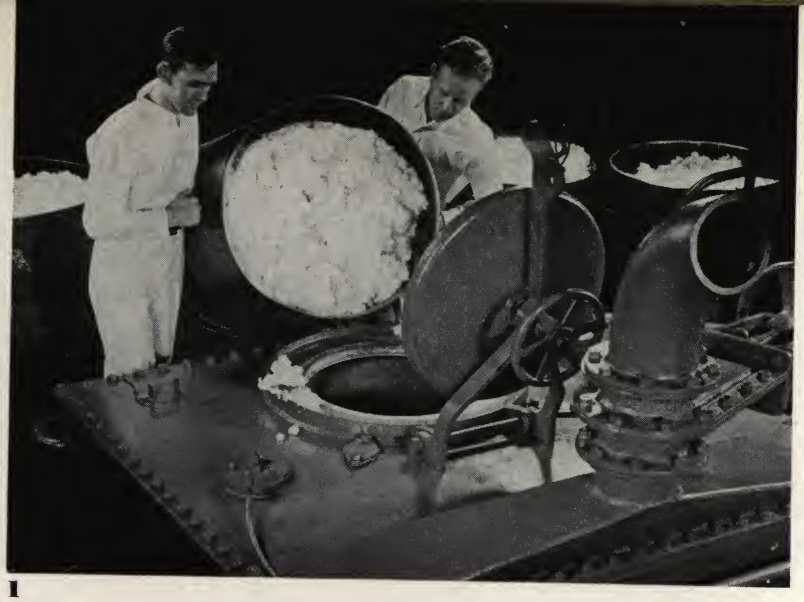
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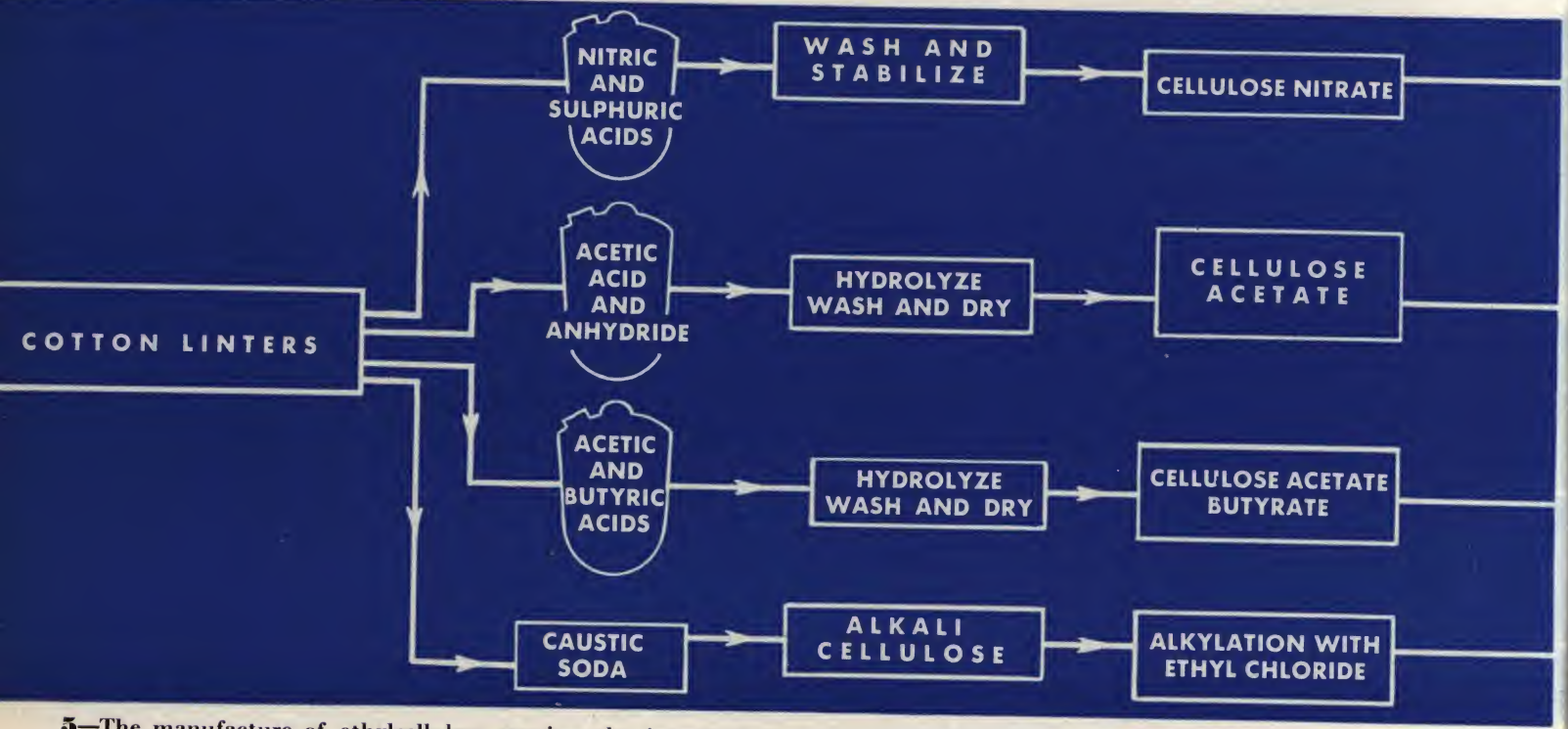
Cellulose Plastics



1

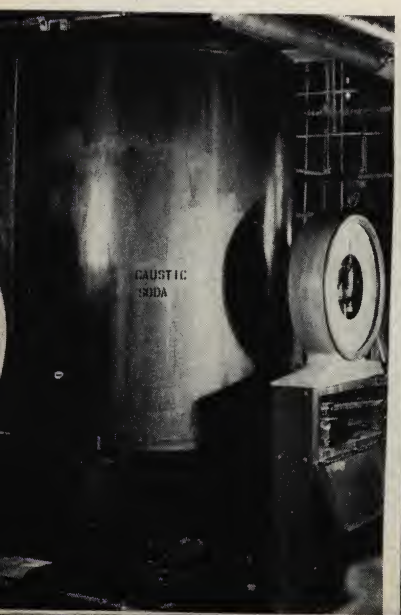
PHOTOS, COURTESY CELLULOID CORP., E. I. DU PONT DE NEMOURS & CO., INC., HERCULES POWDER CO., MONSANTO CHEMICAL CO., TENNESSEE EASTMAN CORP.

1—Cellulose for the preparation of plastics may be obtained from wood or cotton, the latter being the preferred source. The cotton linters are mixed with acids and catalysts in specially built reaction vessels. Powerful machinery stirs the mixture during the esterification reaction

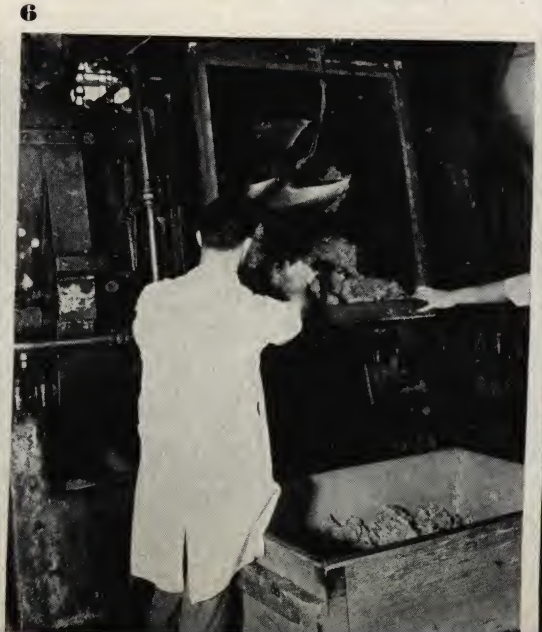


5—The manufacture of ethylcellulose requires the intermediate preparation of alkali cellulose. The caustic soda solution is pumped from a nickle weighing-tank into a nickel reaction vessel. Treatment of alkali cellulose with gaseous ethyl chloride is done under pressure. **6**—Cellulose nitrate is mixed with camphor and coloring materials in a kneader which converts these ingredients into a doughy mass. A batch of material is removed from the kneader. **7**—The kneaded mass is loaded into a filter press

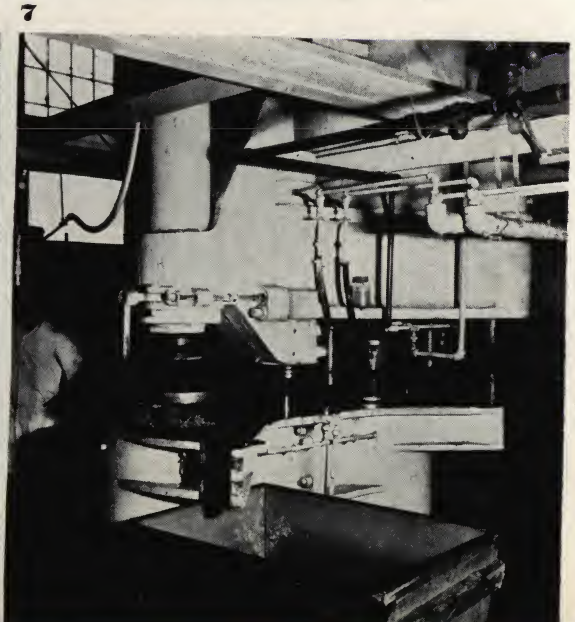
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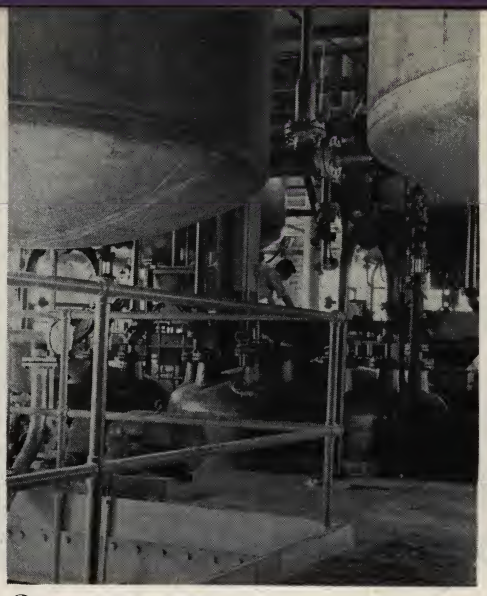


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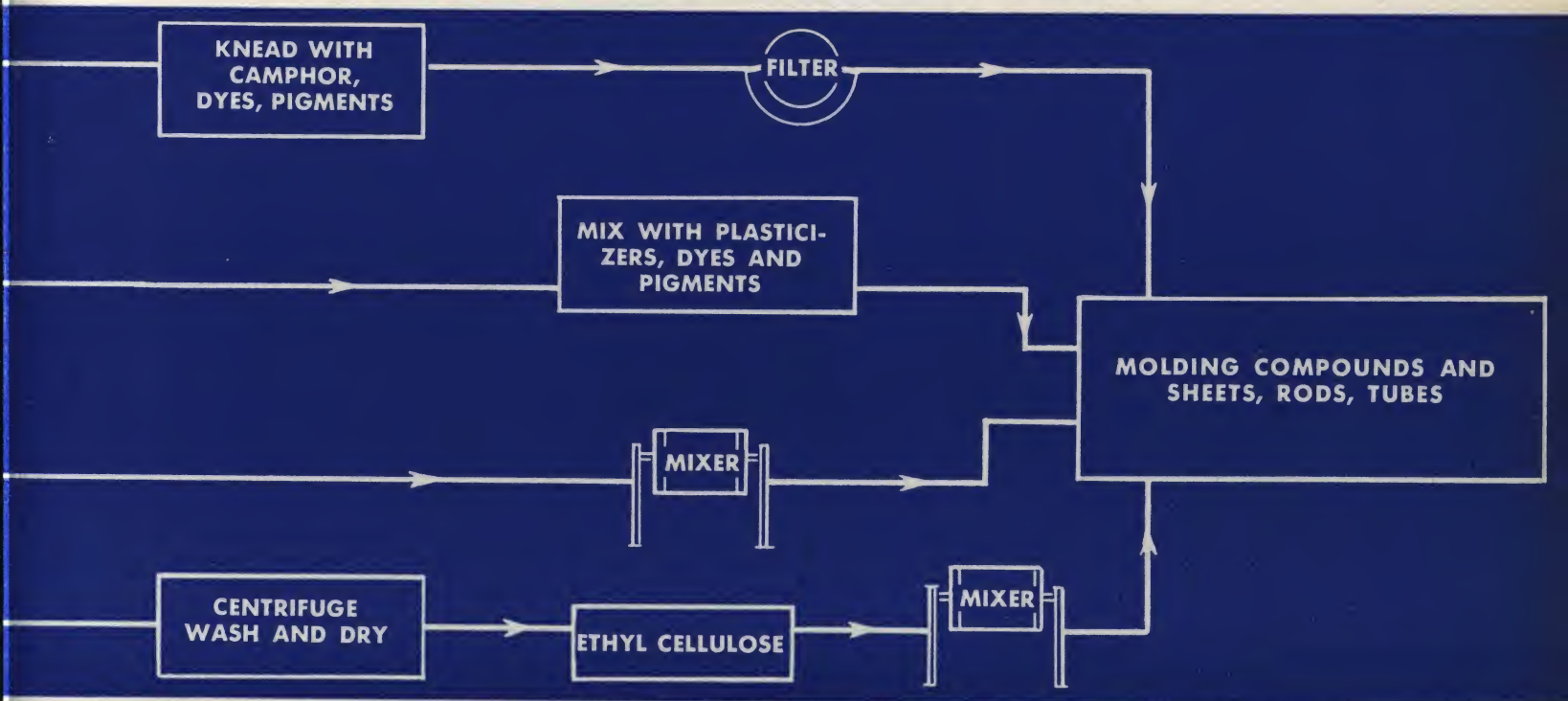


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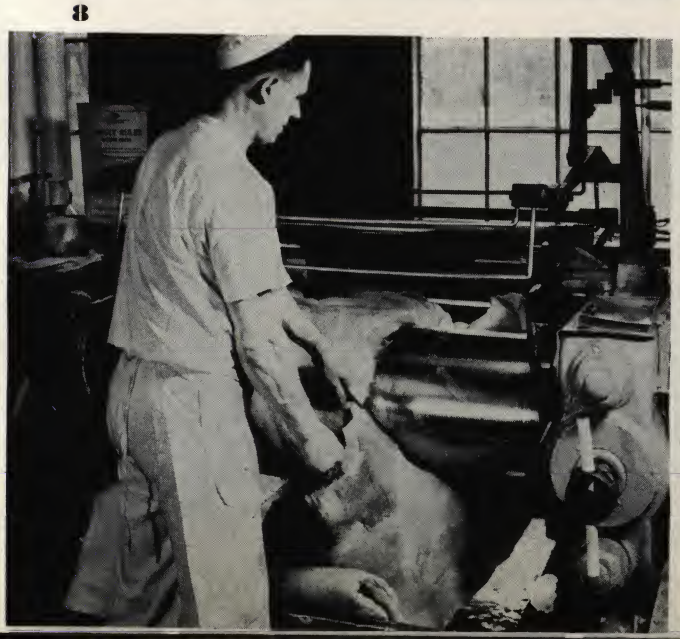
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2—An acetylator tips up and pours out a viscous solution of cellulose acetate butyrate. A drastic transformation of the fluffy cotton has taken place. **3**—Treating tubs in upper foreground where purification and washing are done. Hydrolyzers in upper rear with operator inspecting the product on vibrating screen. After treating, the esters are conveyed to drain bins and then fed to dryers. **4**—A dryer made of stainless steel and aluminum reduces the water content to less than 0.5 percent



8—After filtering the plastic under pressure through wire mesh screens and other filtering media, it is transferred to converting rolls where it is further worked into a homogeneous colloidal mass. **9**—The stock is taken from the rolls in slabs, stacked and pressed under heat into a block from which sheets are sliced. The sheets are seasoned to remove solvents and are flattened and polished between metal plates in hydraulic presses. Some of the slabs are cut into small cubes for feeding into an extrusion machine to make rods and tubes

8



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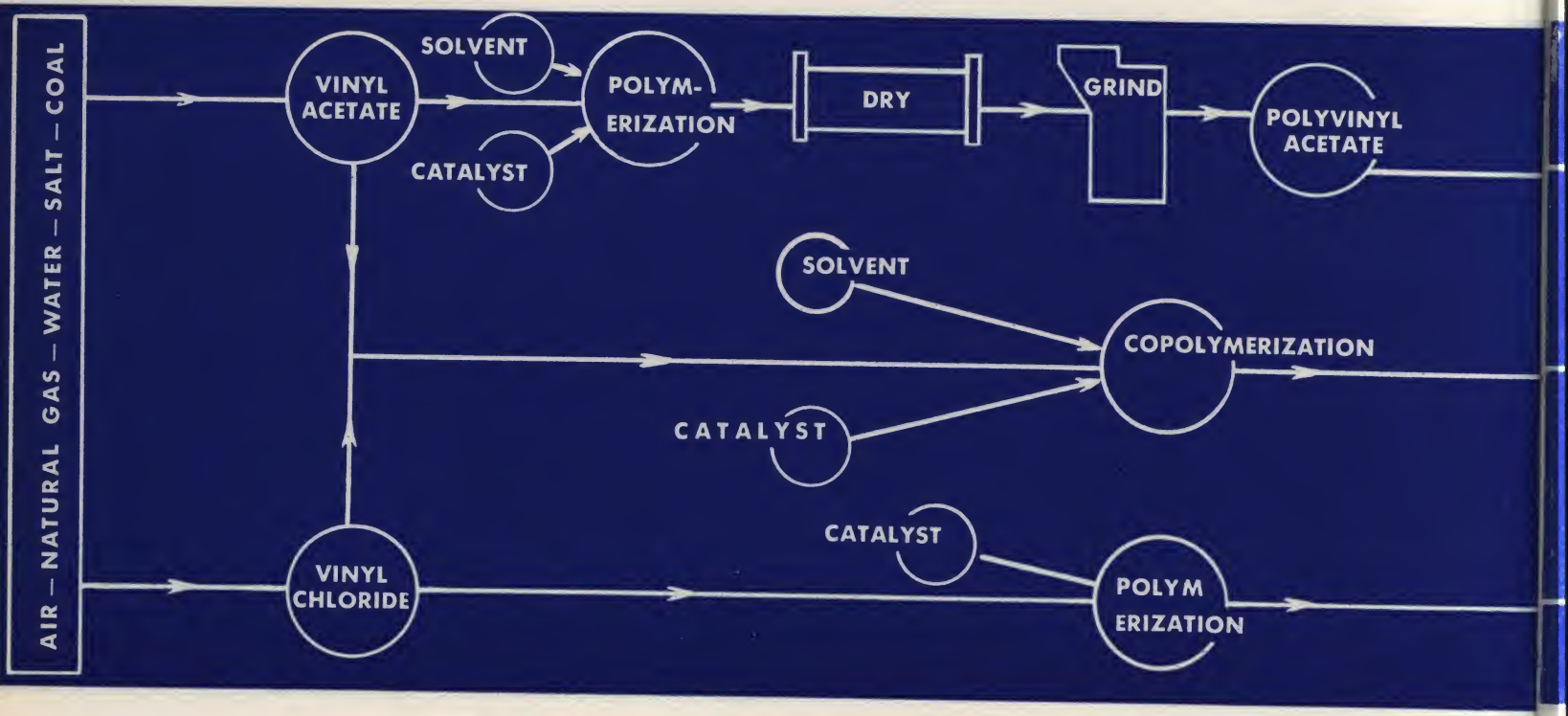


Vinyl Resins



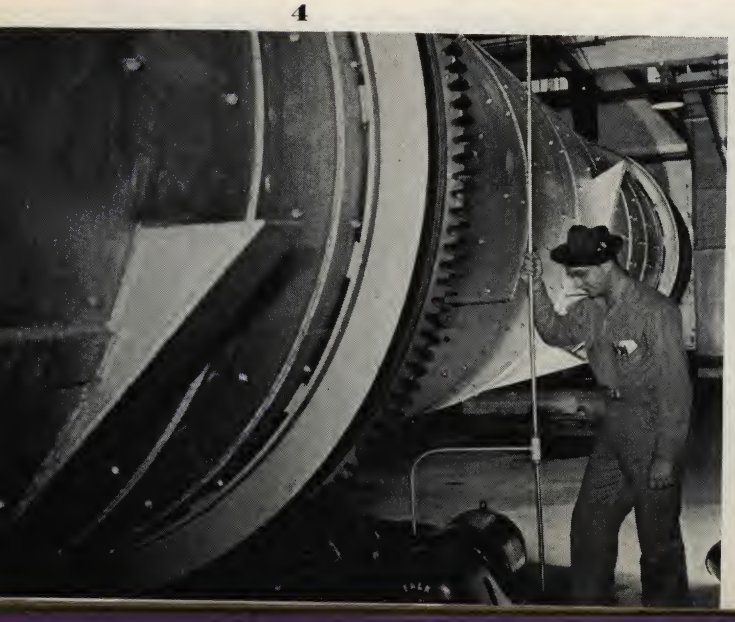
1—Modern resin plants are constructed so that the initial reaction of the raw materials takes place on the uppermost floor and the intermediate products pass in succession to lower stories. A plant of this type is shown above

PHOTOS, COURTESY MONSANTO CHEMICAL COMPANY



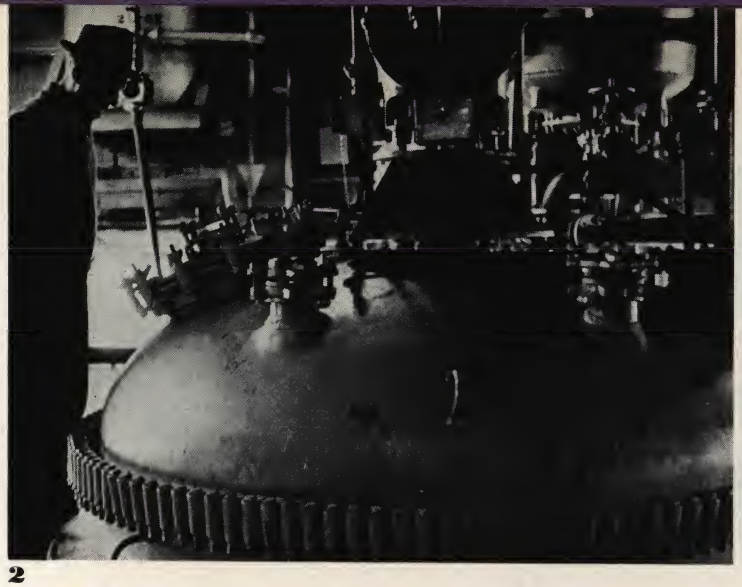
4—The resin is finally recovered as a precipitate which is purified, stabilized and dried. This continuous rotary dryer is the type used for this latter purpose. **5**—Plant operations are largely automatically controlled. Rotameters, recorders, and automatic valves for regulating the hydrolysis, condensation and distillation processes are to be seen on these wall panels

4

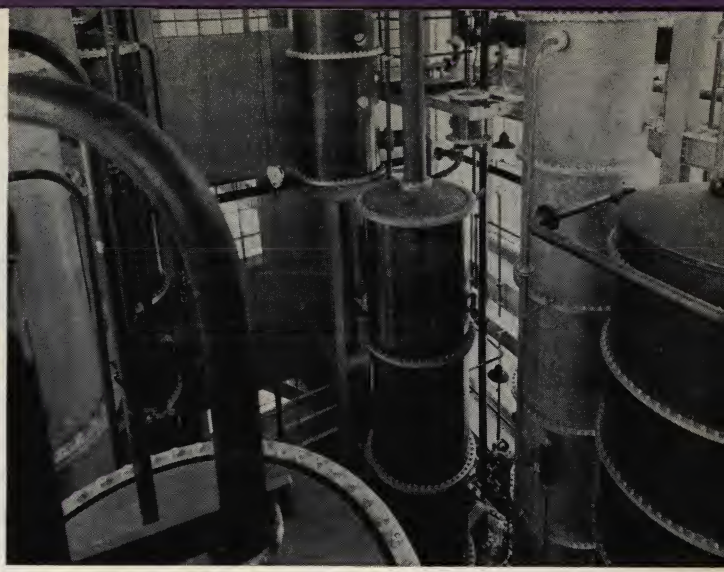


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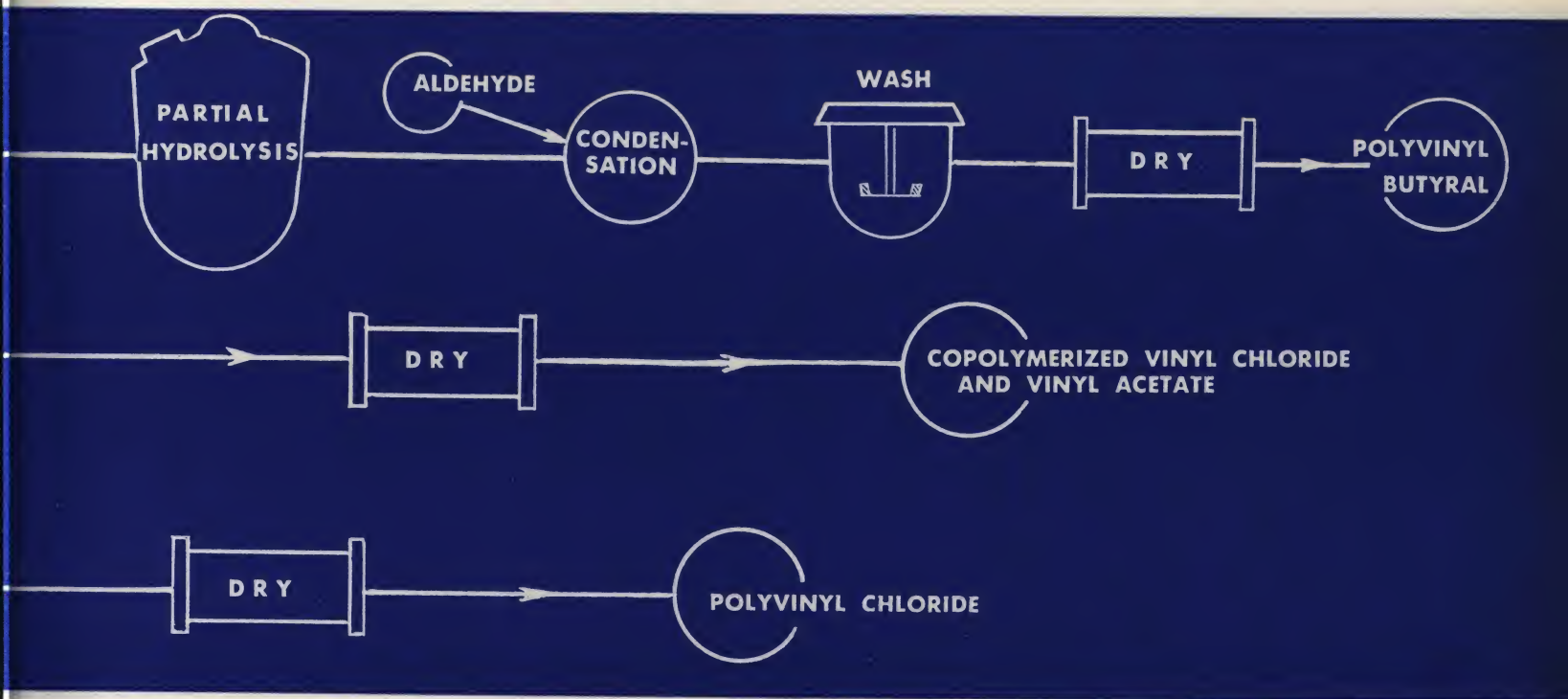


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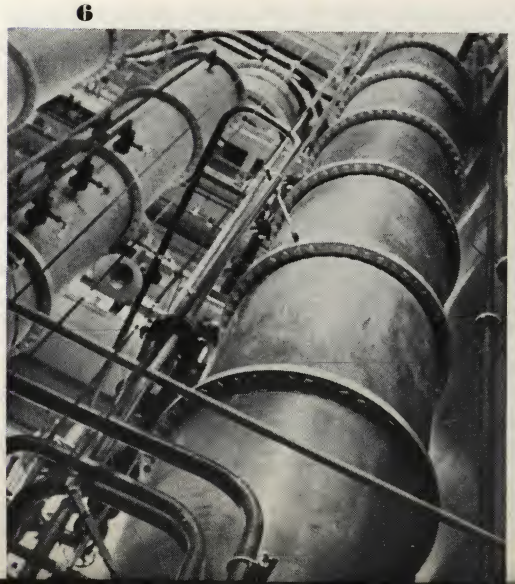
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2—The manufacture of vinyl butyral resin starts with the partial hydrolysis of polyvinyl acetate to yield polyvinyl alcohol which still contains some acetyl groups. This hydrolysis is accomplished in glass-lined kettles, such as the 1750-gallon giant seen above. **3**—Butyraldehyde is reacted with the polyvinyl alcohol-acetate in the presence of solvents and catalyst to yield polyvinyl butyral. Solvents and raw materials must be recovered in these columns

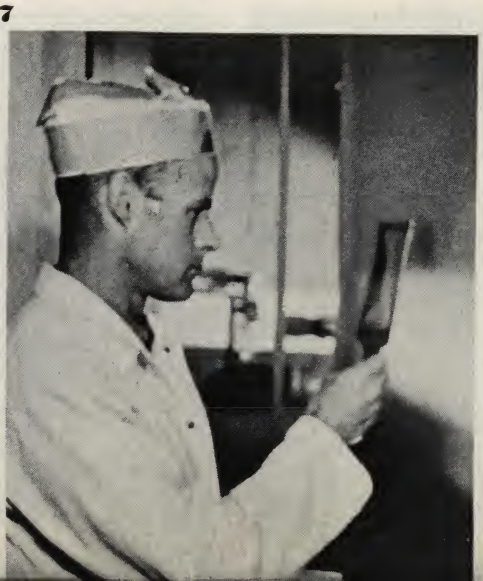


6—Acetic acid resulting from the hydrolysis of the polyvinyl acetate represents a valuable by-product. A special still house is provided for its recovery. **7**—The polyvinyl butyral is made into thin sheets for use in the manufacture of laminated glass. The extruded plastic is here shown being examined for imperfections and contaminating material. **8**—The inspected sheet is wound up in a continuous roll for shipment to the producers of laminated glass

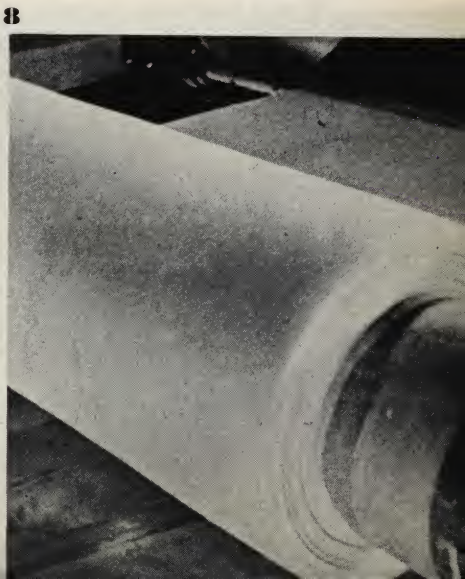
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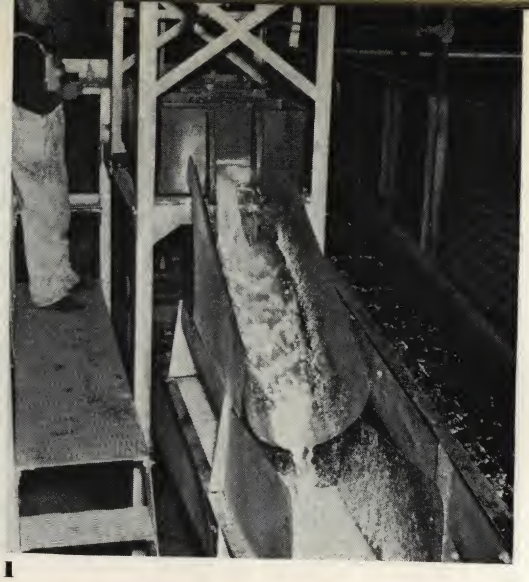
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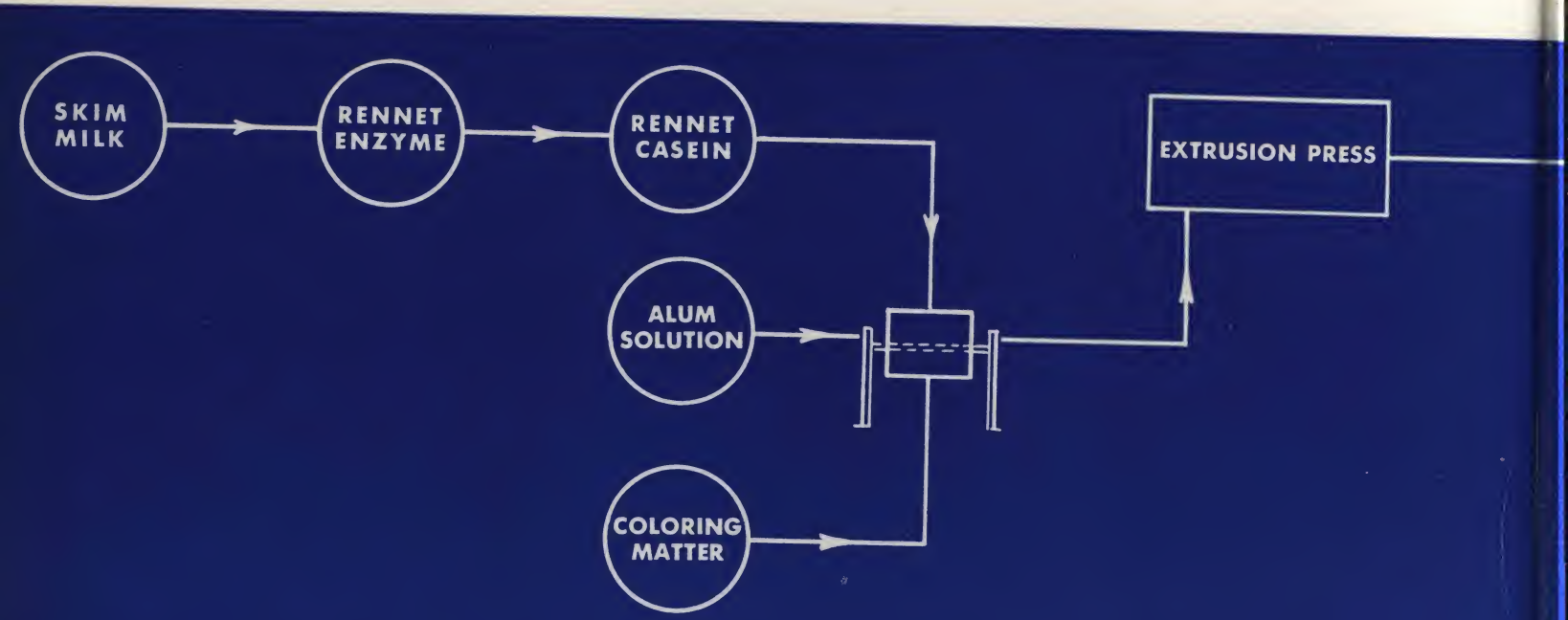
Casein Plastics



1

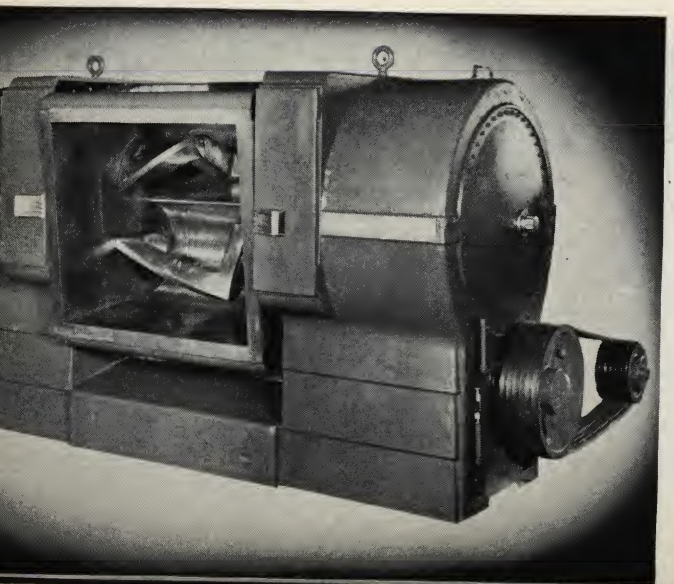
PHOTOS, COURTESY SHEFFIELD BYPRODUCTS CO., PATTERSON FOUNDRY & MACHINE CO., JOHN ROYLE & SONS

1—Casein for plastics is made by treating skim milk with rennet. The curd is separated from the whey in an inclined screw conveyor

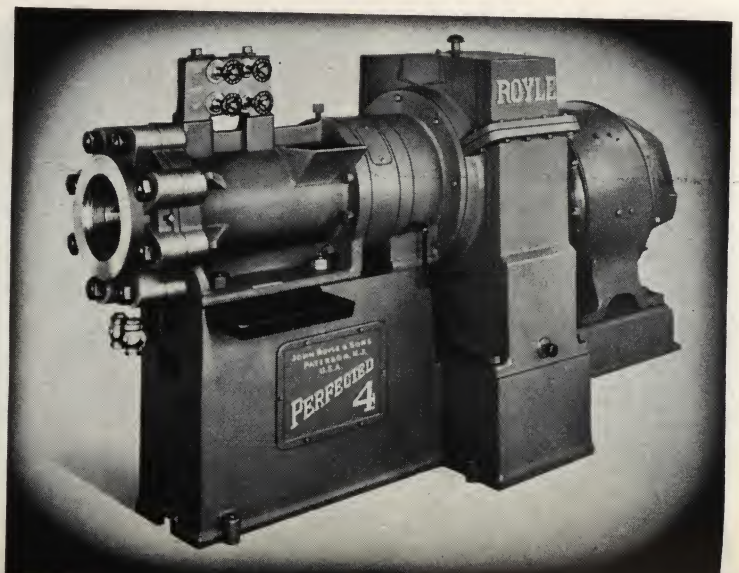


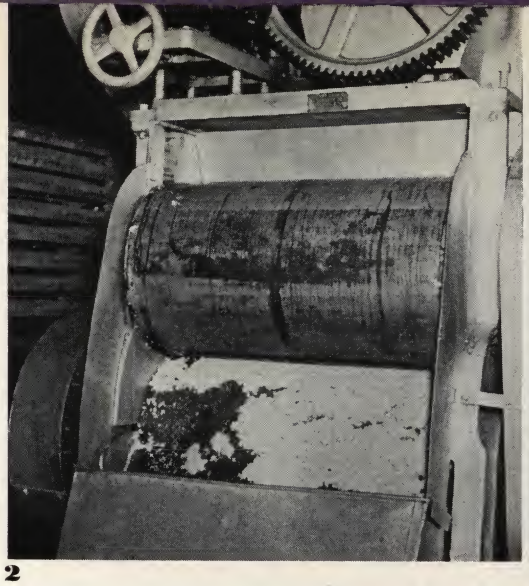
5—A blade mixer, shown below in discharge position, is employed for compounding the casein with plasticizing material and coloring matter. **6**—The colloided mass is fed into the hopper of a screw-type extruding machine and issues as rods of casein plastic

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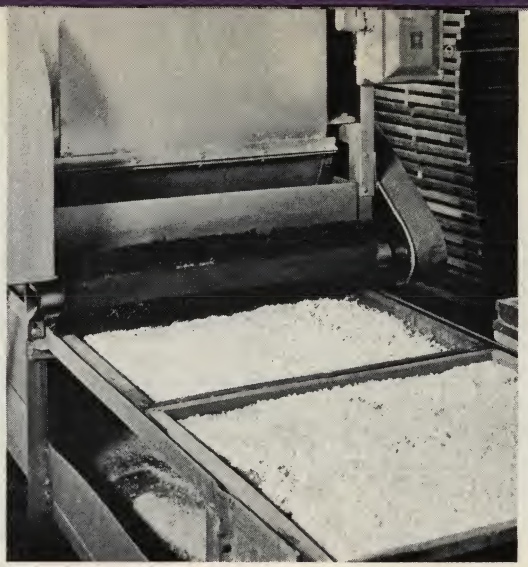


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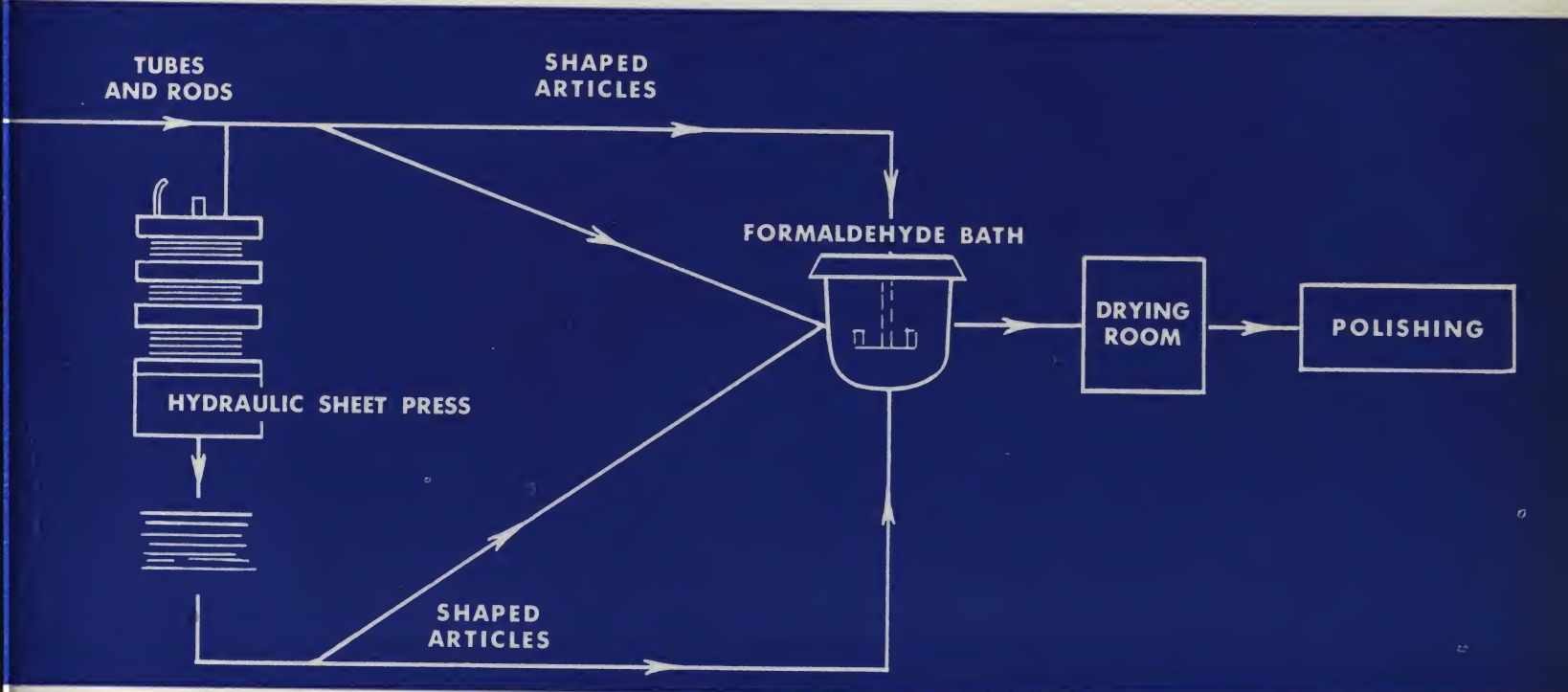


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4

2—The white curds are thoroughly washed and then are continuously fed into a roller press, where the water content is reduced to about 50 percent. **3**—This machine grinds the curds and spreads them out on trays for drying. **4**—The casein is finally dried in a steam heated funnel kiln. The truck containing the trays of wet casein are wheeled directly into the dryer

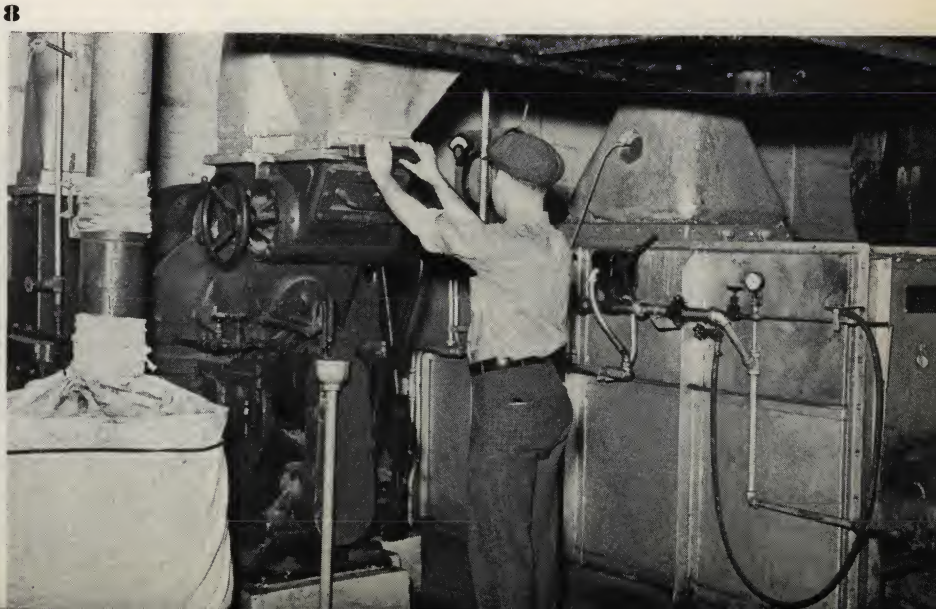


7—Soybeans are a source of another protein used in plastics. A view of the equipment in which phenol and formaldehyde are reacted together with the soybean protein at the Ford plant. **8**—This figure illustrates the grinding of the soybean meal, at the Ford Motor Co. plant

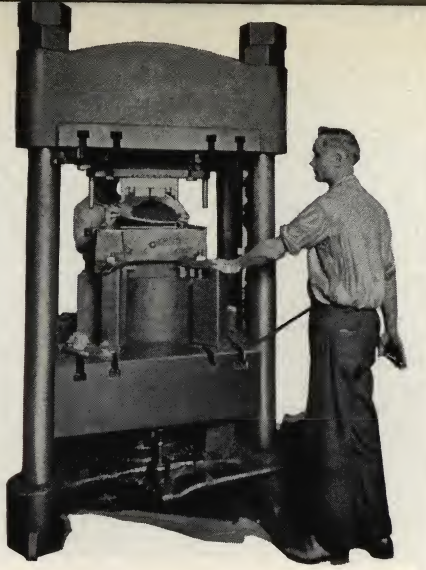
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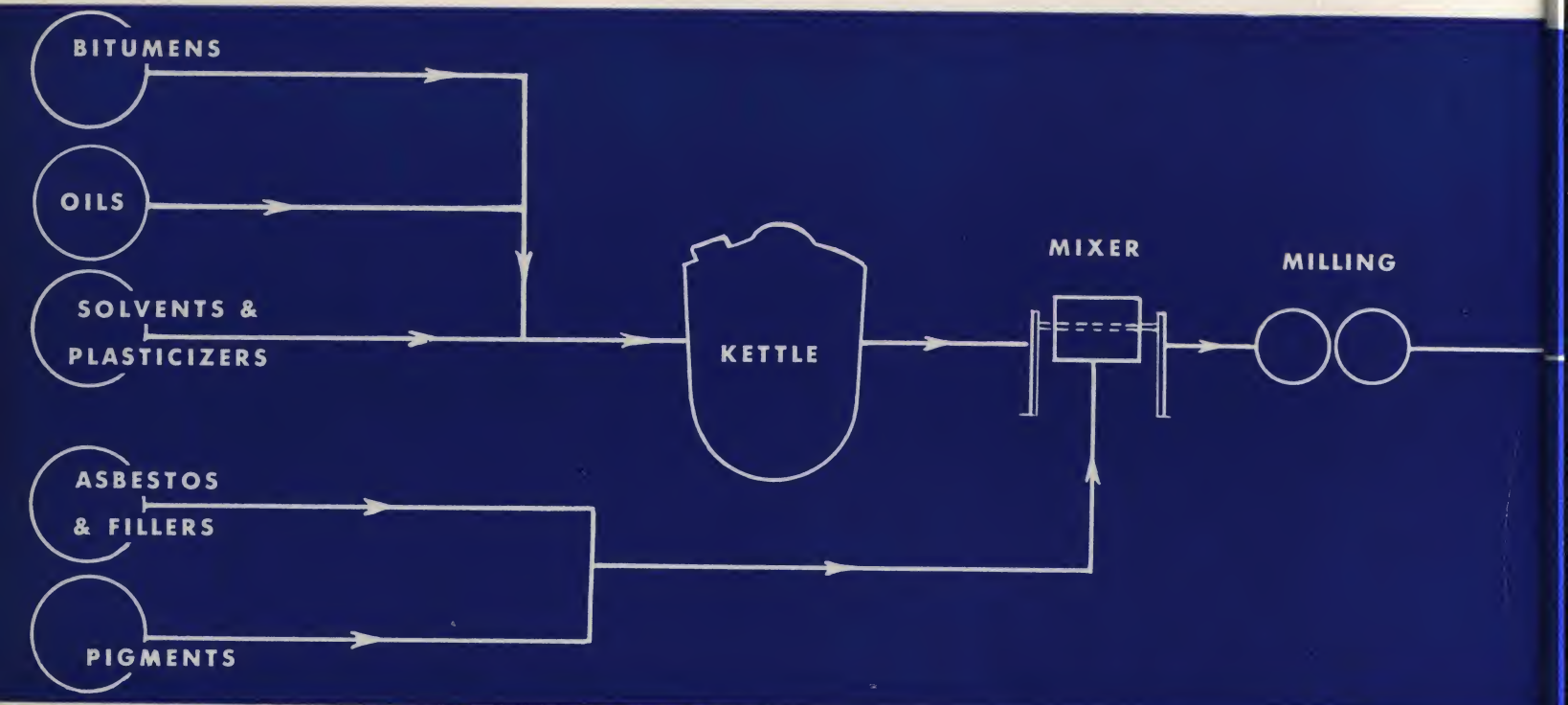


Cold Molding Compounds



1—The nature of cold molding powders is such that each manufacturer makes and uses his own material. The compounds are shaped by compression in steel mold

PHOTOS, COURTESY OF GARFIELD MANUFACTURING COOMPANY

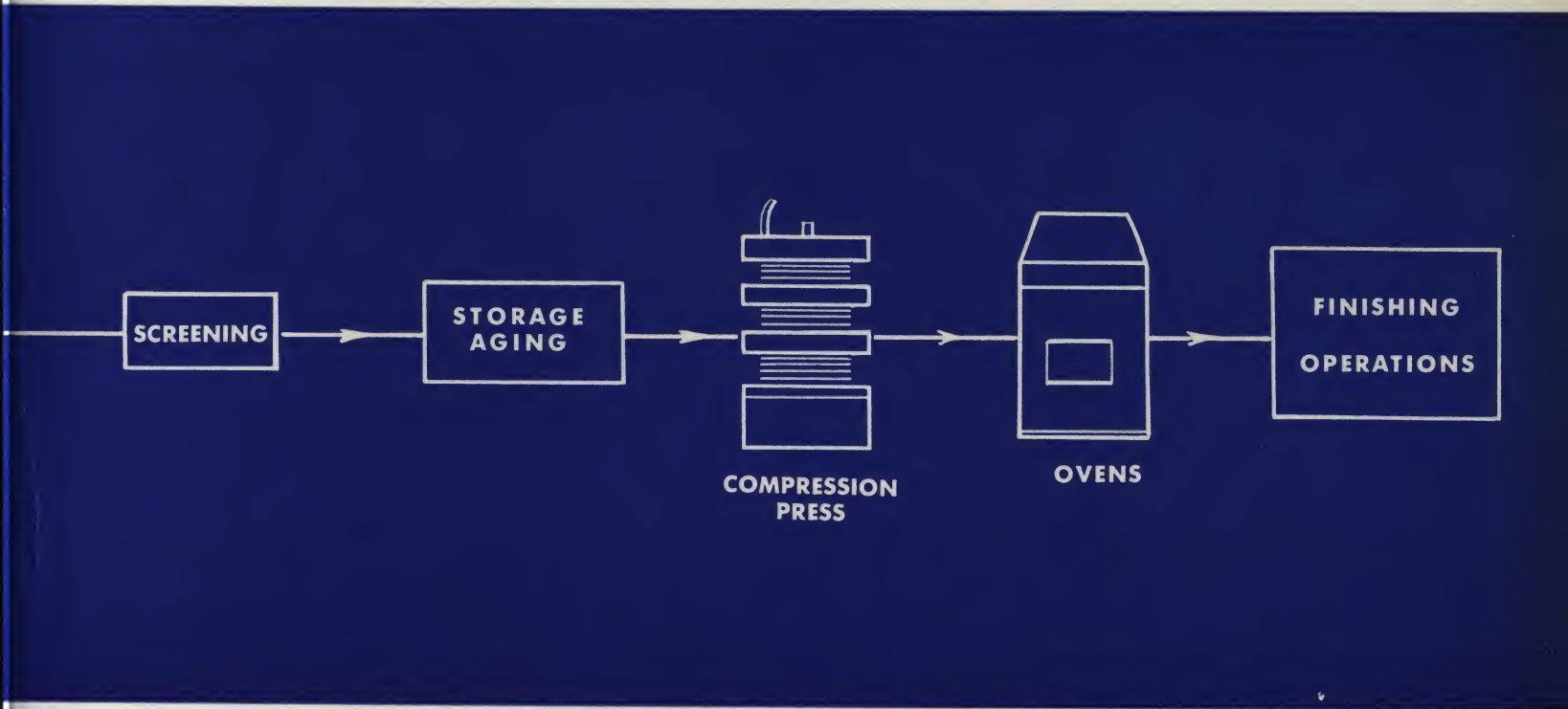


3—When taken from the press, the piece is fairly tough, but must be handled carefully while being placed in the ovens to bake. The baking temperature range is from 300 to 500 deg. F., usually in stages and for varying lengths of time depending upon the mass of the individual article. It is important that the air in the ovens be well circulated during the baking process





2—Each molder has his own formulas and uses various types of bituminous, synthetic resin, and drying-oil binders. In preparing the composition a filler, generally asbestos, is placed in a steam-jacketed mixing machine. The binder is then added and the mixer is operated until the filler is thoroughly coated by the binder and proper granulation is reached



4—Burrs and fins may be removed in tumbling barrels for small articles and by wire brushes on larger pieces. For very close tolerances on larger parts, it is frequently necessary to grind with a fixture either on a disk or belt grinder. **5**—In cold molding, single cavity dies are used for the most part, except on small articles where from 2 to 4 cavities at the most are considered economical

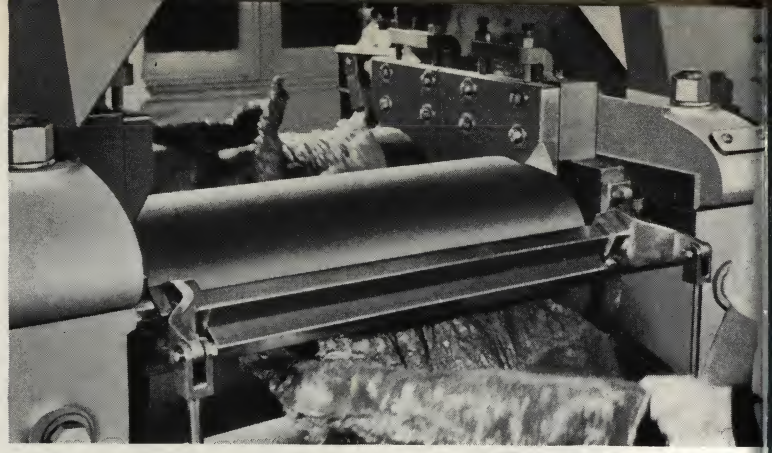
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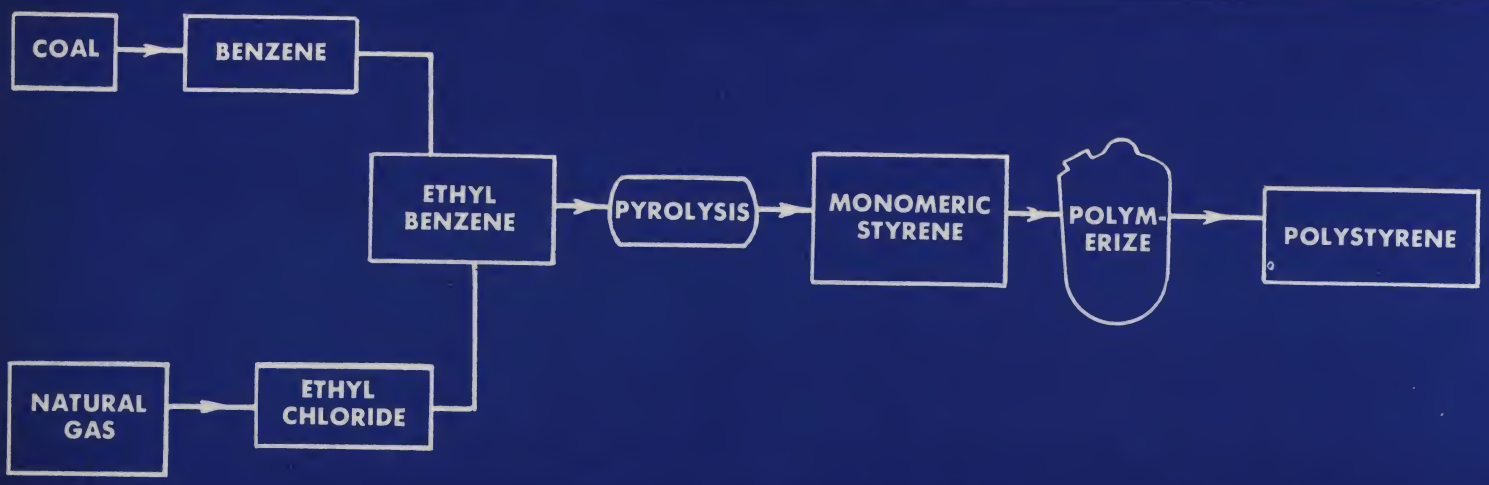


Styrene Resins

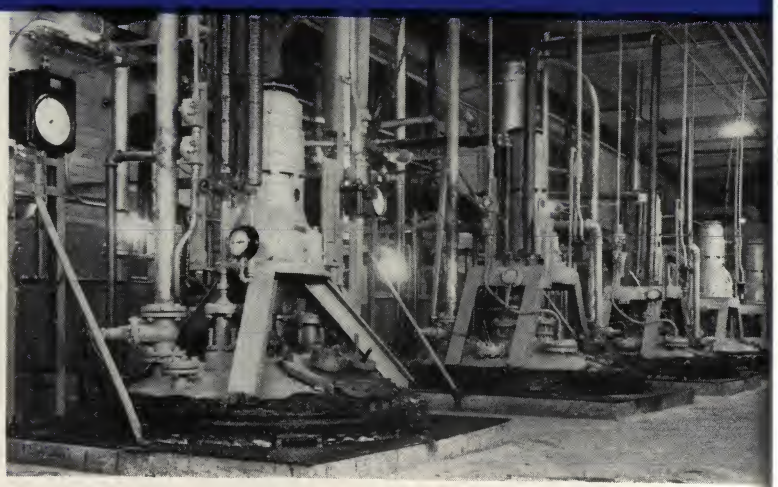


PHOTO, COURTESY BAKELITE CORP.

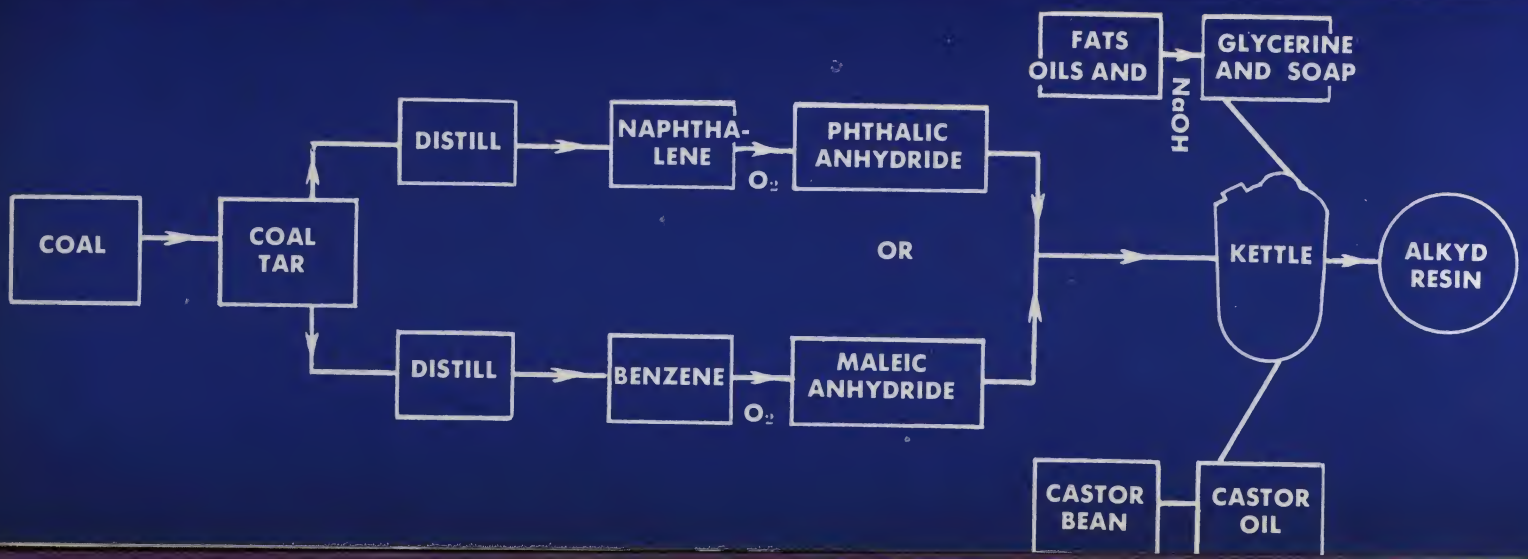
Compounding polystyrene with coloring agents on hot mixing rolls



Alkyd Resins



Typical reaction kettles used in the production of alkyd resins

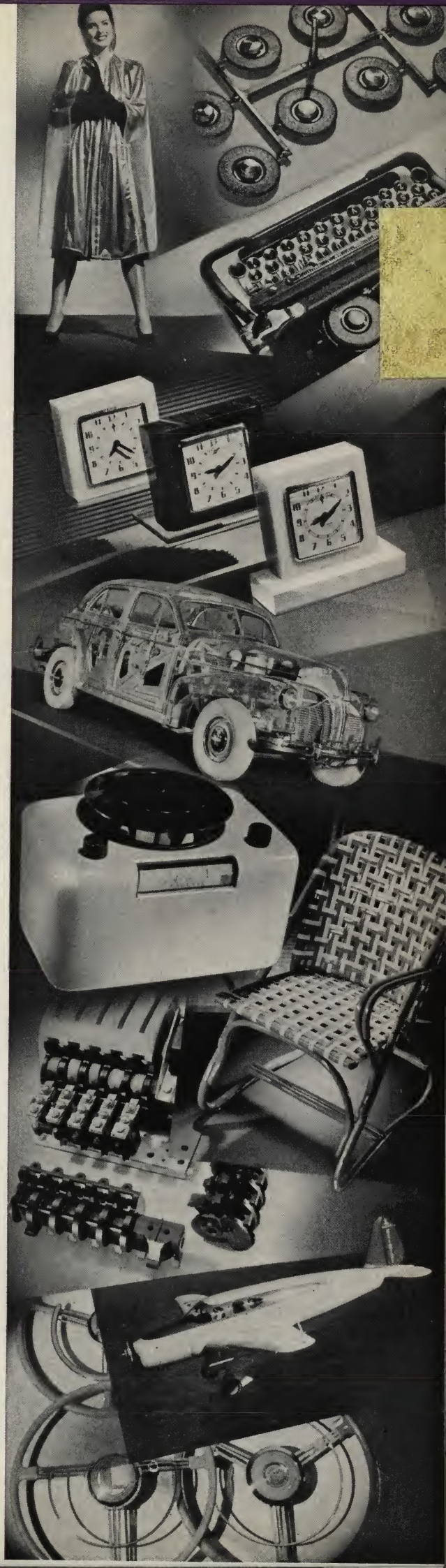


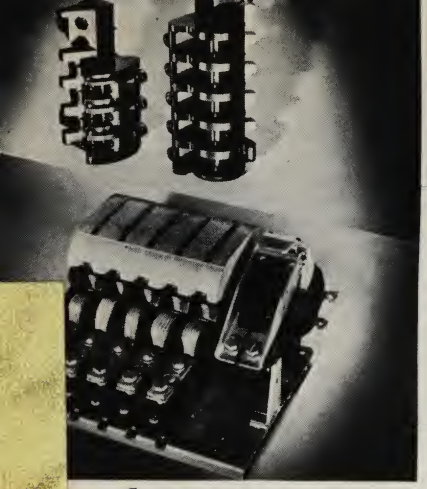
MATERIALS

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Plastics properties chart—Opposite 150





1



2



3

1—The molded shaft of this 5-pole panel type G-E electrical magnetic switch is of Textolite. Used to start, stop and reverse motors, they are operated across the line on voltages up to 600 with current load as high as 50 amperes. 2—Sleek, black, durable housing of this de luxe Barsope lather mixer is of Durez, molded by Central Machine Works Co. 3—Rustproof, hygiene apple corer and slicer of Resinox is molded by Northern Industrial Chemical Company

Phenolic resins (molding type)

PHENOLIC resins are obtainable by the interaction of many different phenols, aldehydes or ketones, and catalysts. The number of possible combinations which may be employed is almost infinite, which allows the preparation of phenolic resins with properties especially designed for various uses.

Molding compounds in general require a type of resin with quite specific properties. Most essential of these properties are rapid cure, rigid set, smooth high finish and good resistance to heat, electricity, water and solvents. Properties desirable in molding compounds are possessed by only a few of the possible combinations which may be used in the making of a phenolic resin. Resins derived from the pure para-substituted phenols such as butyl phenol are useless in molding compound because of their lack of curability, although these products find wide use in the paint and varnish industry. The long-chain meta-substituted phenol present in cashew nut shell oil can be used to produce resins of remarkable electrical properties, but these same resins have a soft, rubbery set which is usually undesirable in molding compound.

The majority of the resins used in molding compound today are derived from phenol, cresol or xylenol and formaldehyde. In spite of the lower cost of cresol and cresylic acid, present practice tends toward the use of phenol itself as the basis for molding compound. One of the sound reasons back of this trend is that phenol can easily be obtained pure and uniform. The cresols occur together in coal tar; the ortho-cresol can be separated in a pure state by fractional distillation but is of no value as such in molding compound, while the meta- and para-cresols are costly to separate and are usually used as a mixture. With the xylenols the separation of the pure individuals becomes increasingly difficult. The manufacture of resins from the cheap cresol or xylenol mixtures is attended by many difficulties, both because of the difficulty of controlling the composition of the raw material and because of the very great differences in the chemical reactivity of the isomeric cresols and xylenols. It is quite possible that if meta-cresol, for example, could be obtained in high purity at a reasonable price it might serve as a base for excellent molding compound.

Similar considerations apply to the other aldehydes or ketones which may be reacted with phenols to form resins. Formaldehyde reacts more rapidly than its

4



4—Smart-looking, lightweight, this "Candid" portable radio by Sonora, is molded of Durez by the Richardson Company

higher homologs such as butyraldehyde, giving the fast cure desirable in a resin for molding compound. The catalysts permissible in molding compound are limited by the necessity of molding in metal molds, which precludes the use of strongly acid catalysts in the final molding compound.

The phenolic resins, which are the basis for the phenolic type compounds, are the largest group of plastic resins and are of the coal tar group. They are obtained by the reaction of almost any phenolic body (such as phenol, cresol, resorcinol and naphthol) with almost any carbonyl compound (such as formaldehyde, acetone, benzaldehyde, furfural—or their reaction products with ammonia) in the presence of almost any catalyst (hydrochloric acid, lime, ammonia).

Chemistry of the reaction

The product obtained from the reaction of phenol and formaldehyde depends primarily upon the following factors:

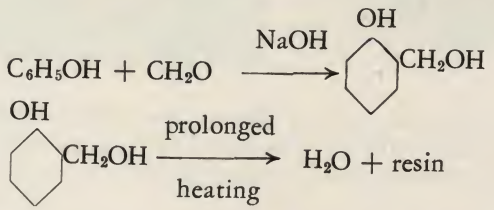
1. *Relative amounts of phenol and formaldehyde.* When the molecular ratio of phenol to formaldehyde is greater than 1:1, the ultimate products are fusible (or thermoplastic) resins or even simple crystalline compounds. The simplest ultimate product of the reaction forms as follows:

$$2C_6H_5OH + CH_2O \longrightarrow HOC_6H_4—CH_2—C_6H_4OH$$

When the molecular ratio of phenol to formaldehyde is somewhat less than 1:1, the ultimate reaction product is a cured (set) resin. Such a resin may be regarded as made up of very large, complicated, three-dimensional molecules in which phenol nuclei are probably linked together with methylene groups.

2. *Natur of catalyst used.* With strongly acid catalysts the reaction tends to go at once to the ultimate product. Consequently, acid catalysts are normally used in the production of "two-step" resins where only a limited amount of aldehyde is combined with the phenol to give a thermoplastic resin which is later mixed with more aldehyde or hexa.

With alkaline catalysts intermediate products are formed which are capable of further reaction, e. g.:



With such catalysts as ammonia or amines the reaction product may contain some of the catalyst in chemical combination.

(*Please turn to next page*)

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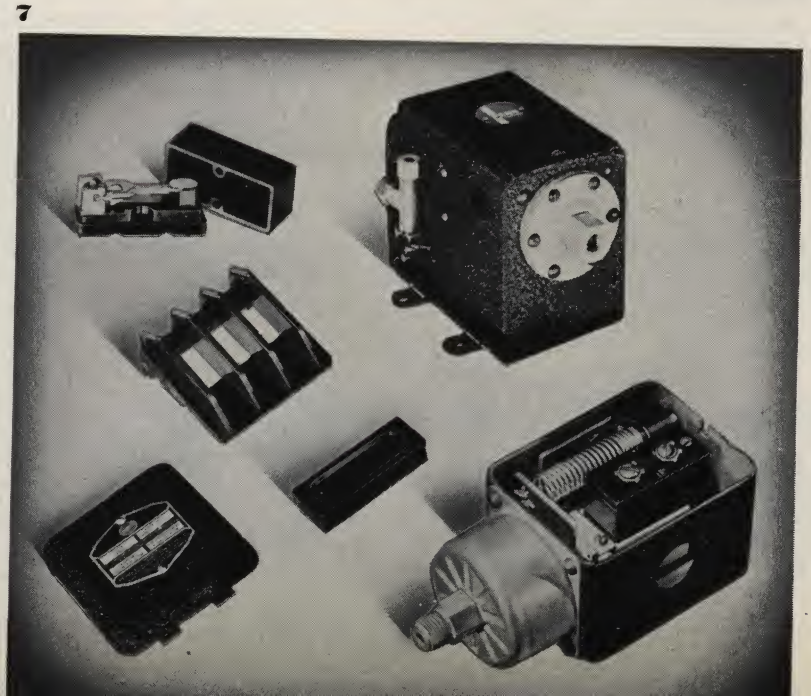


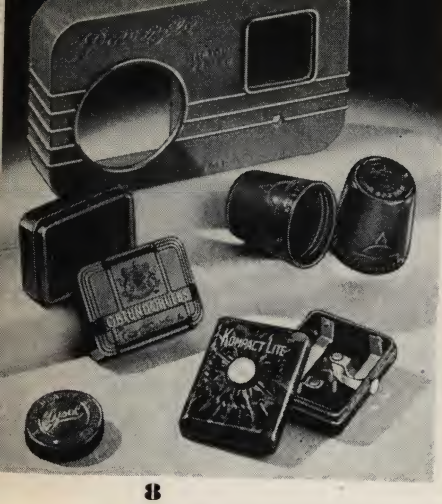
5—Heat-resistant, Bakelite solder paddles, molded by Chicago Molded Products Corp. are used to smooth out molten lead in auto repairing. 6—Ingenious Cord-Away appliance plug molded of Makalot has a split-plug construction to adapt it for various electric devices. 7—Molded Insurok phenolic by Richardson Co. is used by Penn Electric Switch Co. for air compressor and steam pressure control parts

6



7





8



9



10

8—This collection of diversified molded articles of Indur demonstrates its varied applications. 9—Lustrous, permanent finish with strength and rigidity make Durite an ideal material for these re-use containers. 10—Comfortable, warm, mottled arm rests of Resinox. Easily cleaned, wear resisting, they are a boon to theatre managers

3. *Time and temperature of reaction.* Regardless of the type of catalyst used, the intermediate reaction products are convertible to the final products if heated hot enough or long enough.

General characteristics

Thermosetting phenolic resins have the widest utility. The rate of cure or set can be varied to meet almost any industrial requirement. Cured phenolic resins develop great strength and hardness and are resistant to heat, water, organic solvents, acids and mild alkalies. Electrical properties are good enough for all ordinary applications, except where maximum possible resistance to surface tracking or exposure to ultra high frequency are involved. The only important property in which phenolics suffer by contrast with other thermosetting resins is their lack of color stability. Certain types may be made water white, but even these discolor in time, a change which has no especial effect upon other properties. Cured phenolics are rather hard and brittle, although modified types of greater softness and flexibility can be prepared. The compatibility of cured phenolics with other resins and plasticizers is rather limited. Certain phenolics are compatible, however, with rubber, shellac, drying oils and waxes. Cured phenolic resins may be made substantially odorless.

Phenolic resins have a greater coefficient of thermal expansion than metals. They will shrink around metal inserts after molding and hold them tightly. Actual adhesion to metal is slight, resulting in easy removal from the metal mold.

Uncured thermosetting phenolics are available in solid and liquid forms, as solutions in organic solvents and in water, and in the form of colloidal dispersions.

Thermoplastic phenolics have less utility than thermosetting types. Their chief points of difference are in their extremely wide solubility in organic solvents, compatibility with other resins, and relatively poor mechanical strength. In oleoresinous varnishes and in lacquers they impart remarkable durability and weather resistance, coupled with good gloss and fast dry. Good color stability and fair adhesion can be obtained in such compositions.

Developments in 1940

The year has brought to the phenolic molding compound group few new materials but several improved compounds and much general improvement in the physical characteristics of the materials, which while gradual and not outstanding from year to year, over a period of years, is very definite, as in molding time or cycle reduction. Within the year one manufacturer states that through the introduction of new modifying agents he has been able to develop molding compositions of increased flow, faster cures and improved impact and tensile strengths. The major development during 1940 lies in the expanding use of injection molding of phenolic materials (see page 216).

Some progress has been made in the development of materials with greater impact strength, and two new compounds became available—both in black phenolic, with impact strengths of .6 (A.S.T.M.) and .38–.40, respectively. These materials brought to impact compounds a distinctive advantage in the molding process, for due to the long fiber fillers required to make high-impact plastics they have always been difficult to preform and their finish has never been entirely satisfactory. These new materials, however, have a smooth, glossy finish and provide a high-impact material that is far easier to preform as well as molding with a remarkably smooth, glossy finish. They are suitable for heavy-duty moldings where maximum durability and attractive appearance are essential. Moreover, the molding properties of the compounds are outstanding due to the unusual particle size, rather than the fine granular or powdered form usually found in this class of materials. The particle size permits them to be handled satisfactorily in preforming hoppers. Naturally, also, being in a particle size comparable to small pellets, dust loss is reduced.

Phenolic plastics have since their inception been important in the manufacture of electrical devices because of their insulating properties. However, they would

carbonize under arcing. During the year a new arc-resisting material has appeared on the market, this new electrical insulation material having excellent resistance to carbonization under an arc. The material is designed to prevent tracking where there is combined electrical spark and rubbing action as in commutators, heavy-duty distributor caps, etc. One of its characteristics is a dielectric breakdown (A.S.T.M.) V/M of 548. Its dielectric fatigue is 308; insulation resistance R.T. 192,000 Megs.; insulation resistance at 115 deg. C. 814 Megs.; volume resistivity at R.T. 8×10^6 Megs.; volume resistivity at 115 deg C. 2.9×10^4 Megs.

Both in the laboratories of material manufacturers and through the National Bureau of Standards, U. S. Department of Commerce, Washington, the American Society for Testing Materials and other research groups, considerable work has been done to determine the characteristics, limitations and structure of phenolic molding compounds—this work serving a definite purpose to users as well as the industry itself.

The matter of elasticity in the molded or finished piece, for example, is helped by the research that determined the elasticity of standard phenolic compounds, and field experience has already shown that certain grades of molding compounds with improved elastic properties have remedied a number of obstinate cases of cracking around metal inserts.

Definite advancement has been made through Committees D-9 and D-20 of the American Society for Testing Materials pertaining to problems in the production of precision molding. Tentative work has been done on the resistance of plastics to chemical reagents. Much work has been done, both here in the United States and in Europe, on phenolic resin and molding compound technology, and though there remains much to be learned and determined relating to the longevity, tensile and static strength, shear and torsional strength, progress is being made and data as complete as obtainable on metals will be eventually available.

Forms available

The varieties of phenolic molding materials available in powder and granular forms can be appreciated from the following major groupings:

General Purpose, Non-Bleeding, Heat-Resistant, Extrusion Type, High-Impact, Arc-Resistant, Closure Type, Moisture-Resistant, High Dielectric, Acid-, Alkali-Resistant, Friction-Resistant, Sanding, Buffing Type.

Resin boards and blanks are supplied in sheets and stock shapes and can be employed alone or in conjunction with phenolic molding powders.

Method of fabrication

Phenolic molding compounds are sold in powdered or granular form and must be placed in hardened tool steel molds under heat and pressure to be formed into their final shape. The temperature may range from 280 deg. F. to 350 deg. F., while the pressure required is from 2000 lbs. per sq. in. upward. The chemical reaction taking place, known in the trade as "cure," requires 30 seconds to 10 or 12 minutes, depending on the particular class of compound used and the shape and size of the piece.

Typical applications

Automotive and aircraft parts
Electrical insulation
Telephone equipment
Corrosion-resistant apparatus
Housings
Handles and closures
Camera cases
Radio cabinets and parts

Outstanding properties

Dimensional stability
Heat resistance
Water resistance
Resistance to chemicals
Electrical insulating qualities
Moldability

Trade names

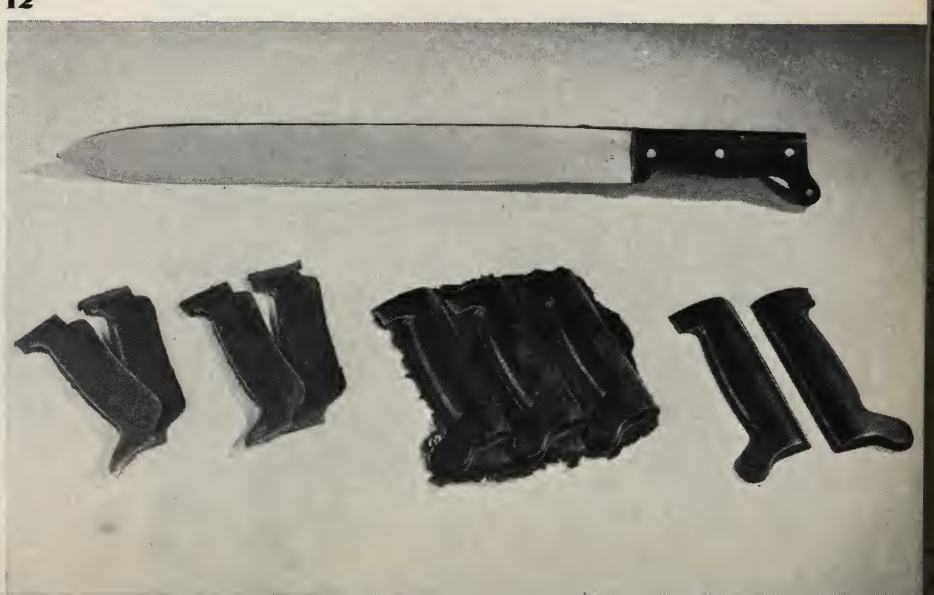
Bakelite, Durez, Durite, Heresite, Indur, Makalot, Resinox, Textolite.

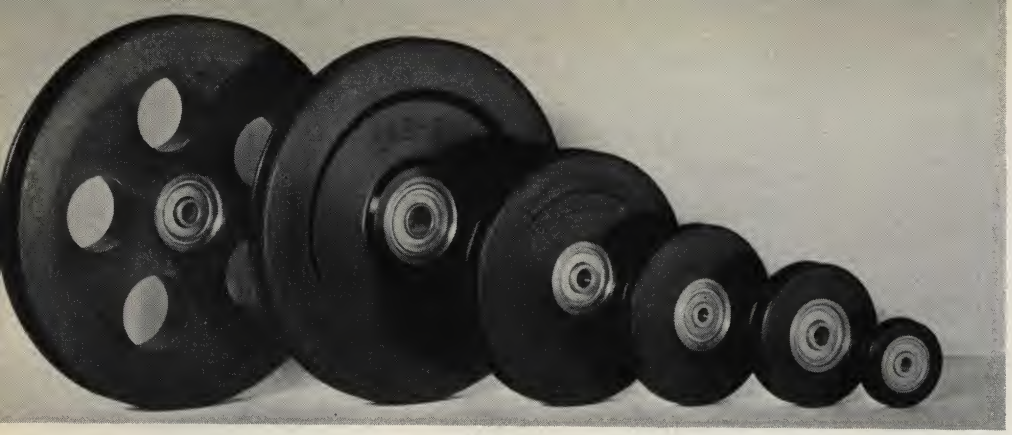
11—Molded Textolite handle of this General-Electric iron has a double thumb rest to relieve strain and a safety light built into the handle. 12—Neither the sweltering heat, the humidity nor the rough shocks of frequent impact diminish the working quality of these machite handles formed from Bakelite Molding Blanks. They are used to hew tropical sugar cane by the Collins Company

11



12





Aircraft pulleys molded of high impact Durite are approved by the U. S. Army and Navy as well as commercial air transport companies

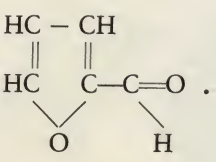
Phenol-furfural resins

OF the great number of resins, both natural and synthetic, that are now commercially available, the types which have the property of rapidly becoming infusible during the molding operation remain comparatively few. It is interesting that by far the most important resins which have this property of first softening and then hardening (curing) when subjected to heat alone are reaction products of an aldehyde with another material, and more specifically the phenols and ureas. Formaldehyde has long been used to react with phenol for the production of a variety of resins, the most important of which have been of the thermosetting type. Two decades ago the first commercial resins were made from furfural and phenol, thus introducing a second aldehyde into this field. Up to the present time these two aldehydes remain the most important in the production of thermosetting resins.

Oat hulls and coal may be considered as the basic materials from which the furfural-phenol resins are made at the present time. Furfural is obtained most economically from pentosan-containing plant products. The parts of plants which are high in pentosans are usually associated with the coverings of the seeds. Although wood contains substantial quantities of pentosans from which furfural can be obtained, certain waste farm products such as oat hulls, corn cobs, rice hulls, etc., offer an abundant supply of raw material relatively rich in pentosans. The furfural is obtained by digesting the pentosan-containing material, e.g., oat hulls, with an acid such as sulfuric acid, and distilling off the furfural. Phenols, as is well known, are obtained as by-products in the coking of coal; the crude "coal tar acids" being separated into various phenols such as phenol C_6H_5OH, the cresols $CH_3C_6H_4OH$, xylenol $(CH_3)_2C_6H_3OH$, etc.

Chemistry of their formation

The structural formula of furfural is



.

It will be noticed that there are three double bonds, and starting with the oxygen of the aldehyde group, these double bonds are arranged as a conjugated system. Since such a system constitutes a resinophore group it is in a large measure responsible for the ability of the furfural to condense with itself to form resinous products. The furane ring is quite stable.

In the reaction of furfural with phenols, the aldehyde group plays an important initial part. However, after the furfural has reacted with the phenol to form the initial reaction product, the furane ring with its conjugated system of double bonds also plays an important part, since it aids in providing a network of thoroughly interlaced, cross-linked molecular chains. The long molecular chains, capable of forming many cross-linkages or *cross polymerization*, provide products capable of complete cure, high strength and exceptional impact resistance. Since the double bonds largely disappear during cross polymerization, and the molecular weight of furfural is relatively high, there is a minimum number of points of attack so that fully cured pieces are chemically inert. They retain polish and rigidity even at high temperatures and molded pieces can be ejected at top molding temperatures without deformation or appreciable loss of dimensions. The presence of the furane ring in combination with the aromatic ring structure of the phenol produces a unique, long drawn out, flat plasticity curve, resulting in unusual flow characteristics, which has made injection molding of thermosetting resins a commercial reality. Since furfural is substantially anhydrous, and has a low water solubility, the mol of water resulting from the reaction of mol proportions of furfural and phenol may be continuously removed from the vapors during the reaction by a gravity separator so that the reaction is anhydrous, with the result that furfural resins of an anhydrous nature are readily produced. Furthermore, the reaction may be so carried out as to produce very stable dark colors that are inherent in the furfural-phenol resin itself.

General characteristics

An outstanding characteristic of the furfural-phenol thermosetting resins is their flat plasticity curve. This means that in molding, the composition flows readily under most difficult molding conditions without segregation from the fillers which makes them admirably suited for the molding of difficult long flow or large parts, and provides great latitude in the molding of the most difficult work.

The furfural-phenol resins as ordinarily used do not go through the characteristic *A*, *B*, and *C* stages of the phenol-formaldehyde resins. The ring structure of furfural inhibits gelation, so that the rubbery, non-flowing *B* stage is avoided, and the resins maintain their flow characteristics at temperatures just slightly above temperatures required to induce plasticity over relatively long periods of time. As a matter of fact, molding compositions made from these resins may be kept in a heated reservoir under pressure for relatively long periods, and injected from the reservoir into a closed mold cavity in continuous injection molding. In actual injection molding operations the potentially reactive furfural-phenol resins have been kept sufficiently plastic for a period of 45 min. to inject and mold continuously. It is therefore not necessary to confine injection molding to thermoplastic materials.

On the other hand, at temperatures of 350 to 375 deg. F., a very rapid exothermic cure takes place. The furfural-phenol resins therefore provide a basis for molding compositions which flow readily either in injection or ordinary pressure molding until the mold cavity is filled and the full hydrostatic pressure is developed, and then cure rapidly as they come up to curing temperatures. The avoidance of the rubbery stage, and the ready cross polymerization at molding temperatures results in accuracy of dimensions and insert positions, and a rigid non-leathery cured part of high accuracy both as to dimensions and surface.

Since chromophore groups may be developed in the reaction of furfural and phenols, dark-colored molding compositions wherein a part or all of the color resides in the resin itself, are readily provided. This results in outstanding depth and permanency of colors especially in brown and black moldings.

A characteristic of interest to molders is the stability and freedom from scorching (sometimes called *burning*) of the furfural-phenol resins at high molding temperatures. In order to increase the per diem output of a mold, high temperatures and shorter cures are often used, but with many thermosetting compositions this results in a high percentage of rejects due to burns. The stability of furfural-phenol resins at high temperatures enables the molder to avoid this difficulty and increase the output from a mold without producing a high percentage of rejects. Furthermore, the pieces are sufficiently rigid at these high temperatures to permit hot pulling. Where furfural-phenol resin molding compounds are used the keynote of the organization is high operating temperature and a large per diem production from the presses even with difficult molded parts.

Developments in 1940

The introduction of new modifying agents is one of the outstanding developments in 1940. Increased flow, faster cures, improved impact and tensile strengths, have been accomplished during the past year. Special varieties of resins have been developed that are especially adapted for particular purposes, many of which are outside the molding field.

Forms available

Potentially reactive one and two stage resins, pulverized. Liquid resins. Fusible resins and varnishes. Modified resins. Molding compounds using various fillers.

Methods of fabrication

Heat and pressure molding, positive, flash, transfer and injection molding; laminating.

Typical applications

Various well known mechanical and electrical articles and parts, containers, radio cabinets, etc.

Outstanding properties

Superior moldability because of flow and curing characteristics, rigidity when hot, and permanence of dimensions even at top molding temperatures.

Freedom from *scorching* or *burning* at high mold temperatures.

Chemical inertness and water resistance.

Stability of black and brown colors.

High heat resistance.

Superior electrical properties.

Trade name

Durite.

Larger molded radio cabinets are coming more extensively into the field. This R.C.A. unit of Durite with its simple, straight line design demonstrates this trend



Cast phenolic resins

PREPARATION of cast synthetic resins from phenol and formaldehyde can best be pictured under two general reactions in organic chemistry—condensation and polymerization.

It is generally assumed that the condensation reaction results in the formation of intermediate resinous products of low molecular weight. In this operation 1 mol. of water-clear synthetic U. S. P. phenol is mixed with substantially more than 1.5 mols. of U. S. P. formaldehyde, supplied commercially as a clear, aqueous solution of 37 percent strength. To accelerate the reaction or resinification a basic catalyst, usually caustic soda or caustic potash, is introduced and the mixture is heated in a nickel or stainless steel kettle at 70 to 100 deg. C. for periods varying from 10 minutes to 3 hours. As the chemical combination of phenol with the formaldehyde takes place the water-clear mixture darkens slightly in color and increases in viscosity. This reaction is principally controlled by temperature and time factors, pH measurements and viscosity readings, to give end-products of varying physical and chemical properties. The alkaline resin at this point is concentrated in the reaction kettle by heating under vacuum to remove approximately 75 percent of the water. As the elimination of this water takes place the resin becomes quite sirupy and at the proper end-point organic acids are introduced in sufficient quantity to acidify the mass and clarify the color which now ranges from water-clear to amber. The product has the consistency of honey.

Before the final concentration of the light resin sirup under further vacuum to the finished intermediate condensation products various plasticizers, modifying agents, dyestuffs, etc., are introduced in the reaction kettle. In chemical parlance resins at this point are known as heat-reactive, fusible, soluble products. As their name suggests, they may be thinned by heating and are soluble in a number of proprietary solvents including acetone, ethyl alcohol, isopropyl lactate, etc.

Molds in a wide variety of shapes and sizes are prepared in advance and placed on skids for preheating in steam-heated ovens. When the hot resin has been dehydrated to the proper end-point it is drawn from the bottom of the vacuum kettle into pouring pots preparatory to the actual casting operation. The resin base

1—Liquid resin poured into a latex mold which in turn is set in plaster form striking bas relief display or decorative panels. Created by W. L. Stensgaard & Associates, Inc., using Catalin and Monsanto Cast Phenolic



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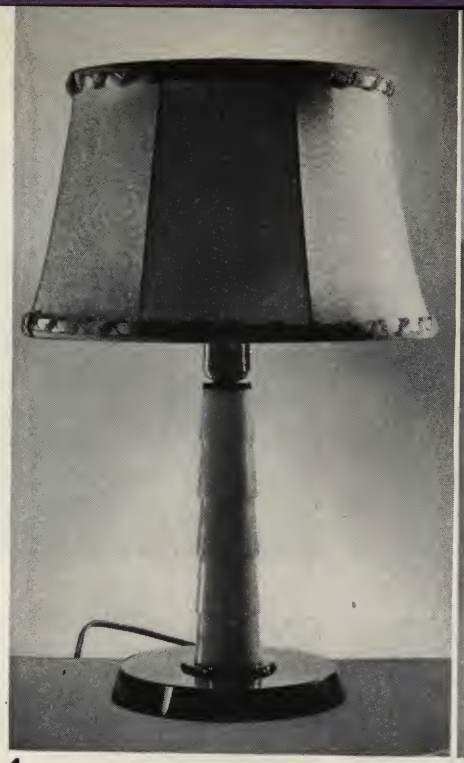


3



2—Transparent, colorful Bakelite cast resinoid hairbrush by Empire Brush Works is nonflammable and holds bristles solidly in place.
3—Monsanto translucent mottled cast phenolic forms the illuminated top panel and bar below the mirror on the Rowe vending machine. Fabricated by Ortho Plastic Novelties Co., Incorporated

4—Lampstand and base of this smart modern lamp are cast of Gemstone in a split mold. 5—Sculptured Catalin figures with a velvety finish are cast in inexpensive, non-metallic latex molds by Dr. and Mrs. Eric L. Alling



4



5

may be an opaque, translucent or transparent natural color or it may be a solid blue or yellow mottled with white. Such an effect is accomplished by stirring into the basic stock a sufficient quantity of a white pigmented resin to give a pleasing mottled or marbled effect. From the very nature of the operation it is quite obvious to the reader that innumerable combinations and patterns are possible to meet the most exacting color tastes. Colorability has long been recognized as one of the outstanding merits of cast phenolic resins and it makes little difference whether a customer demands a vivid or pastel color or the softer shades of grey and brown.

In the second phase of the chemical reaction the fusible soluble resin is converted by polymerization to the final form. This is a change under heat from low-molecular weight liquid resins to the tough hard high-molecular end-products. For this conversion the resin may require curing at temperatures seldom exceeding 85 deg. C. for periods up to 5 days at atmospheric pressures. The steam-heated ovens are maintained at constant temperatures by precise thermostatic control. Chemical conversion is gradual with a progressive change from a soft, tacky gel to the final product without loss in weight. It is in this form that it is supplied to various fabricators who fashion it into the finished articles of commerce.

One modification of the polymerization reaction is the procedure used by one cast resin manufacturer to supply plastic sheets in varying thicknesses. Instead of pouring the resin into the conventional profile or split molds it is cast in special boxes for hardening to a "soft gel" stage. The polymerization is interrupted momentarily while the block is cut into sheets on a conventional celluloid slicing machine. After a further cure of 2 to 3 days at 75 to 78 deg. C. it is finished.

General Characteristics

By virtue of their remarkable physical properties cast resins are able to meet the many demands required of a



6

6—Ingrained beauty is inherent in the Bakelite Cast Resinoid Motorola radio cabinet of Galvin Mfg. Co. Unlimited color ranges and variegated effects are possible

modern plastic. Unusual ranges in transparency, translucency, and opacity are permissible merely by controlling the size of the water droplets without the use of pigments. Further addition of dyestuffs and pigments permits a wide variety of shades and hues both in plain colors and in attractive mottled effects.

Because of their brilliancy and glassy transparency it might be assumed that cast resins possess inferior strength. In spite of the total absence of fibrous fillers, materials commonly used in the molded types, the compressive, tensile, and flexural strengths of the cast products are unusually high and wholly adequate for practically any application. Furthermore these products are non-inflammable and non-absorbent. They possess little or no odor, are tasteless and hygienic.

With such merits it was only natural to meet the demands of the laminator for a light-colored phenol resin



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8



9



10

7—Miniature Marblette piano by Art Bronze Co. hides cigarettes in its novel top. 8—Increasing use of plastics for furniture hardware is shown in these Bakelite Cast Resinoid knobs and pulls. Made by Bassick Co., they are smooth and durable. 9—Catalin aquapearl, fashioned into stylish costume jewelry (D. Lisner & Co.) and handbags (Deauville Bag Co.), is an important fashion note. 10—Marblette supplied cast phenolic sheets for this handsome piece of "period" furniture. The configuration emulates the malachite and lapis in the original. Created by Mrs. G. Howard Davison

in liquid form for laminating thin sheets of paper together into attractive light-colored translucent panels for industrial and decorative uses such as Venetian blinds, advertising signs and displays, lamp shades, graphic charts for permanent records, radio tuning dials, etc. This modern odorless, laminating varnish produces a product which is strong, durable, waterproof, and heat-resistant. It is receptive to embossing, printing, and stamping operations. Perhaps its outstanding merit is almost unlimited color possibilities.

Cast phenolic resins have excellent adhesive properties. Laboratory and field tests have proved, it is said, that the use of these alcohol-soluble products simplifies the application, control, and utility of resin glues for hot-pressed plywood. The products obtained are waterproof and vermin-proof and have shear strengths which are from 15 to 20 percent higher than those formerly obtained with dry film glues.

Developments during 1940

For many years manufacturers of cast phenolics were handicapped by the difficulties surrounding the production of castings from anything but open straight draw molds. Because no metal could be substituted for lead in the casting of phenolics, the problem resolved itself to a method of economically obtaining, in lead, sections of a split mold which could be quickly assembled into a complete mold unit. Through the application of the slush mold principle, and using substantially the same technique, lead sections were produced and found to be accurate and easily handled. By clamping them into watertight units, a satisfactory two- or three-piece mold became available to the industry.

From this advance it was a logical step to the cold mold procedure. Here the outside dimensions of a casting are reproduced in lead, using a regular dipping arbor. Into the lead mold is then placed a core, properly

centered so that it is equidistant from the sides of the lead mold on all surfaces. Between the core and the mold the resins are poured and cured after which the core is removed and the hollow casting taken from its mold.

Forms available

Cast polished sheets 12 in. by 24 in. in various thicknesses
Unpolished sheets cut from blocks 32 in. by 72 in. in various thicknesses
Cast rods, sheets, tubes, and blocks
Special profile castings
Two-tone castings
Split mold shapes
Resin solutions in organic solvents
Liquid cements
Clear and opaque casting resins for hot or cold setting

Methods of fabrication

Users are supplied with castings in a fully hardened and easily workable form according to accurate blue prints submitted by the customer. Thereupon the castings are fashioned to give the final finished product by one or more standard machining operations including sawing or cutting, drilling, threading, forming, carving, embossing, turning, milling, ashing, polishing, etc. (See page 232.)

Casting: Heat-setting liquid resins are poured into suitable molds of glass, rubber, or lead, and heated for 48 hours at 78 deg. C. (See page 226.)

Typical applications

Industrial cabinet housings
Gear shift knobs
Novelties and decorative articles
Individual letters for signs
Advertising displays
Radio boxes
Kitchen utensils and handles
Brush backs
Interior lighting fixtures
Adhesives for wood veneers and grinding disks
Laminating varnishes for light-colored translucent panels
Impregnating resins

Outstanding properties

Machinability
High tensile and impact strength
Non-inflammability
Rigidity
Colorability from transparency to opacity

Trade names

Bakelite Cast Resinoid, *Gemstone*, *Catalin*, *Marblette*, *Monsanto Cast Phenolic*, *Prystal*

11



11—Simplicity of design distinguishes Telechron's richly colored clock case of Monsanto cast phenolic. 12—Highly polished, sleek, with good structural strength, garment hangers and hat trees in all shades are made of clear Catalin by Belmar Mfg. Co. 13—Colorful articles for gaming tables made from Marblette stock molds are tough in service. Chessmen are by E. S. Lowe Company

12



13





1



2

1—No raw material is more widely used in molding lampshades than urea. This one of Bakelite ivory translucent is a stock mold. 2—Durable and decorative, Snapet ivory Chime-Master housing of Beetle molded by Marks Products Co., Inc., has decorative bas relief figures and fluting

Urea resins

UREA resins were first produced commercially in this country in 1928. The basic resin is thermosetting or heat-hardening, and one that can be termed truly "synthetic" since its principal constituents may be made from a combination of four gases: Ammonia, Carbon Dioxide, Hydrogen, and Carbon Monoxide.

Chemistry of formation

Urea resins are produced by reacting urea, $CO(NH_2)_2$, with commercial formalin (an aqueous solution of formaldehyde, H.CHO), under varying conditions of time, temperature and alkalinity or acidity. Water soluble intermediate products have been identified as containing mono-methylol urea ($NH_2.CO.NH.CH_2OH$) and dimethylol urea ($CH_2OH.NH.CO.NH.CH_2OH$). Commercial urea resins are frequently condensed further than the methylol urea stage for the purpose of modifying resin properties such as plasticity, viscosity, etc.

The intermediate resins for many applications are used in admixture with cellulose in some form such as paper, pulp, or rayon fibers before finally curing to an infusible, insoluble product. The curing is usually effected by heat in the presence of proper catalysts which are in most instances of an acidic nature or substances which in the presence of the resin tend to become so. The completely cured product is infusible, insoluble and resistant to water and organic solvents.

General characteristics

The unpolymerized urea resins are water clear, water soluble and fusible. As a water soluble resin, this compound is frequently used to treat paper, cloth, and wood veneer for laminating. The resin may be used as the principal bonding material for the laminated sheets or on the surface laminae of sheets where other resins have been used as the principal binder. The surface treatment permits the possibility of surface color without necessitating the use of the resin throughout the lamination. As an impregnator of wood veneer it serves as a binder and protective coating without discoloring the wood.

Another form of the urea resin is used in the manufacture of baking enamels or surface coatings. In combination with alkyd resins the material may be used to provide a hard surface coating resistant to alcohol, grease, and fruit acids and is available in a range of many brilliant colors.

Urea resins are widely used as adhesives in a solution or in combination with some diluent or filler and are set by the hot press method. A cold setting cement for bonding plastics has also found quite a satisfactory use.

Other applications for urea resins in solution are for the treatment of textiles to render them crush-proof, water-repellent, and to alter the finish and to increase general serviceability.

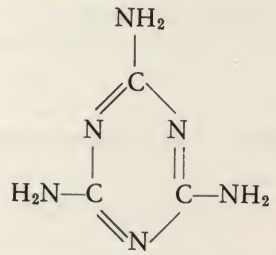
In combination with a finely divided alpha cellulose pulp, the urea resin may be formed into a molding compound, available as a powder or granule. Since the resin is colorless, and the pulp a pale white, the addition of dyes permits accurate color reproduction. This compound is molded at temperatures approximating 285 deg. to 315 deg. F. and at pressures ranging from 3000 to 6000 lbs. to the sq. in. The rate of setting or polymeriza-

tion depends upon the temperature applied, the curing agents present, and the form of the part. During such treatment the cured part takes on the exact configuration of the die, becomes insoluble and will not soften again under heat.

The finished part, whether it be as a molded article or a laminated section, is practically inert—that is, it is odorless, tasteless, and resistant to organic solvents. Its surface is hard and durable. The molded section is rigid, extremely light in weight, and quite strong, but under shock can be broken.

Melamine resins

Melamine resins and compounds were made available commercially in the United States in 1939. Melamine may be prepared from dicyandiamide, which in turn is obtained from cyanamide. Melamine is usually considered as having the following formula:



Melamine resins may be formed by reacting melamine with formaldehyde. The resulting resin is water-clear, water or water and alcohol soluble, and thermosetting.

In solution this resin may be used to treat paper and wood veneer for laminating purposes. It may be used as the principal bonding material for laminated sheets, or on the surface laminae of sheets where other resins have been used as the principal binder. This surface treatment permits the possibility of surface color without necessitating the use of the resin throughout the lamination. As an impregnator of wood veneer, it serves as a binder and protective coating without discoloring the wood itself.

Melamine resins have also been introduced in the form of molding compositions. These are molded by compression methods, the rate of setting or polymerization depending upon the temperatures applied, the form of the piece to be molded, etc. During such treatment, the curing piece takes on the exact configuration of the steel die, becomes insoluble and will not again soften under heat.

The finished article, whether molded or laminated, is very inert; it is odorless, tasteless and highly resistant to organic solvents, hot water, weak acids and alkalis. The molded or laminated surface is extremely hard and resistant to abrasion.

Developments during 1940

As far as the general characteristics of urea plastics are concerned, there has been very little change during the past year. Attention is directed to the use of urea adhesives, in plywood manufacture and particularly in the airplane industry. *(Please turn to next page)*

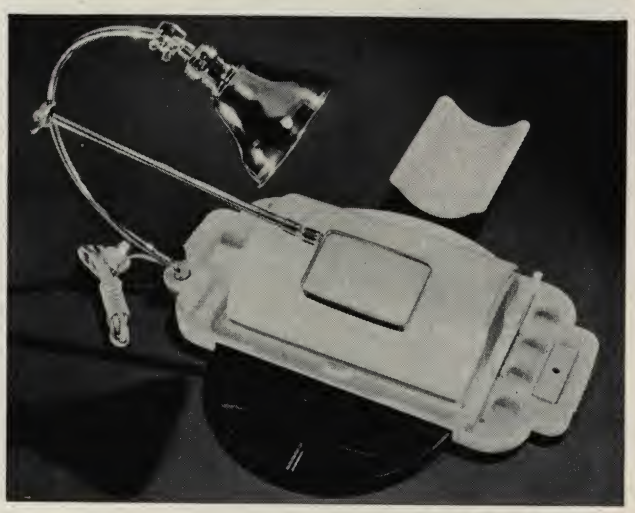
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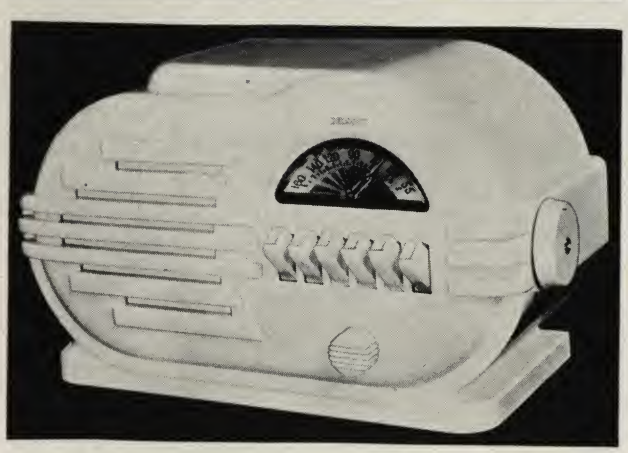
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3—Unlimited design and color possibilities adapt urea for novelty timepieces by Westclox. Ivory Travel-clock is housed in Beetle, and blue desk clock in Plaskon. 4—Automatic Sifon-Gauge, molded of Bakelite urea by American Molding Co., is alcohol-resistant and washable. 5—Portable Pro-Care manicuring unit is compact lightweight, will stand repeated scouring, and is comfortable for operator and customer. Complete assembly is molded of Plaskon and Textolite by General Electric Company



6



7



8

6—A major outlet for cosmetic packaging and closures, ureas are used throughout the Mary Chess line. Molded of Plaskon by Colt's Patent Fire Arms Mfg. Co. and A. J. & K. Co. 7—Belmont radio cabinet styled to incorporate high colors of urea, is molded of Insurok by Richardson Co. 8—Innovation in commercial fluorescent fixture design this louvered "egg-crate" of translucent Textolite, is manufactured with Beetle resins by General Electric Co. It acts as a light diffuser and masks the lamps behind it

With the advance of fluorescent lighting, naturally, urea plastics have found an increased use in the tombstone sockets, and also in louver lighting.

It is also to be noted that there has been an increasing tendency toward the use of striated and mottled colors particularly for radio cabinets.

The introduction of melamine as a partial substitute for urea to improve water resistance and molding properties of molding compositions and of laminating varnishes may turn out to be an important contribution to the industry. While the use of this newer material up to the present time has been largely in development work, there has been sufficient quantity sold to prove the value of it in urea resin chemistry.

Forms available: Urea resins

Resins in solution for laminating
Resin in solution for textile treatment
Adhesives, a heat-setting solution
Cold-setting cement (solid and liquid components)
Molding powder or granule

Typical applications: Urea molding materials:

Closures
Display boxes
Housings
Buttons
Lighting reflectors
Tableware
Electrical wiring devices

Typical applications: Urea resins:

Translucent and opaque laminated sections in color
Adhesives
Baking enamels in any color
Textile finishes

Outstanding properties of polymerized urea resin:

Unlimited translucent or opaque colors
Odorless and tasteless
Rigid, shatterproof, hard surface
Thermosetting
Excellent light diffuser
Very lightweight

Trade names: Urea resins

Bakelite Urea, Beetle, Plaskon.

Forms available: Melamine

Resins in solid form and in solution for laminating, etc.
Molding powder or granule

Outstanding properties of melamine polymerized resin:

Thermosetting
Colorless and light fast
Odorless and tasteless
Resistant to hot water and organic solvents
Heat resistant

Trade name:

Melamac

Cellulose acetate

CELLULOSE acetate plastics belong to the family of cellulose derivative plastics which include the inorganic and organic acid esters of cellulose, such as cellulose nitrate and cellulose acetate, respectively, and the cellulose ethers, of which ethylcellulose is the outstanding example. Cellulose is the base common to all types. It is produced in a highly purified state from cotton linters, or from wood pulp.

Cellulose acetate has been known since the early experimental work of Schützenberger and Naudin from 1856 to 1869. These early cellulose acetates were mostly of the completely acetylated type, soluble in chloroform and other chlorinated hydrocarbons which are regarded as highly toxic. Miles in 1905 discovered that acetone-soluble products could be obtained by a partial saponification of the highly acetylated esters. It was not, however, until the outbreak of the World War that any substantial commercial progress was made. War demands for airplane wing coating materials accelerated the development and production of cellulose acetate and also suitable solvents and plasticizers for that purpose. Plants left idle at the close of hostilities were soon occupied in the manufacture of cellulose acetate rayon. Adequate and economical production of cellulose acetate thus assured, investigators turned to plastics, the first of which appeared commercially in this country about 1927.

Chemistry of their formation

Both chemical and physical processes are involved in the manufacture of cellulose acetate plastics. They are not pure chemical compounds, but rather solid or colloidal solutions of cellulose acetate in plasticizers.

Cellulose acetate itself is made by treating cotton linters with acetic acid and acetic anhydride in the presence of a catalyst such as sulphuric acid. Cellulose triacetate of about 63 percent acetic acid content is formed by the reaction. It is soluble in the treating acids forming a heavy dope. The dope is cured with the addition of water to partially hydrolyze or deacetylate the cellulose triacetate. The cellulose acetate is then precipitated in water, washed and dried, in which form it is soluble in acetone and is suitable for the manufacture of plastic materials.

For the conversion or colloidalization of cellulose acetate, plasticizers are required. These are generally oily liquids of high boiling point and low vapor pressure which, in most cases, have a solvent or gelling action on the cellulose acetate. Several types are used, either singly or in combination, the amount and type depending upon the characteristics desired in the finished plastic. Among the plasticizers commonly used are: dimethyl phthalate, dibutyl tartrate, triacetin, para-

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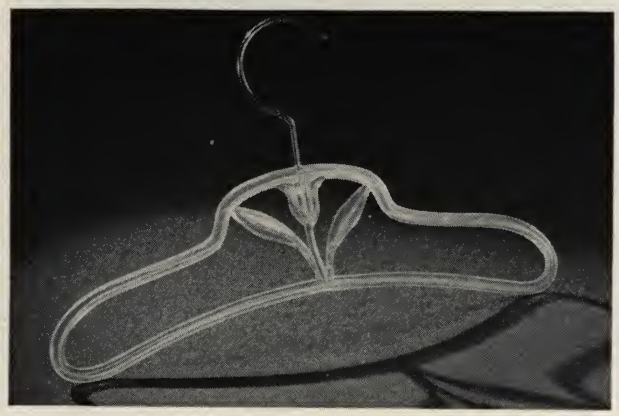
1—Fittings in practically all of America's automobiles are of molded cellulosic materials. This collection of Tenite molded parts illustrates the wide variety. 2—Dainty dining alcove has furniture made from woven extruded Lumarith in colors which blend with the general color scheme. 3—Stylish "Scarlett" cologne bottles are of Bakelite cellulose acetate, molded to form by Plastics, Inc., and glass. Top portion is gilded



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toluene ethylsulphonamide. To this number may be added triphenyl phosphate, which also has excellent fire-retarding properties.

The cellulose acetate is mixed in a kneader with suitable quantity of plasticizers and volatile solvent such as acetone and alcohol until a doughy colloidal mass is obtained. The colloid is then worked on heated malaxating rolls with the addition of dyes or color pigments until the colors are thoroughly incorporated and dispersed throughout the mass. Subsequent steps in the process depend upon the form of plastic desired. For molding powders, volatile solvents are removed and the material is ground in a mill to the desired size of granules. If cut sheets are preferred, slabs are taken from the rolls, stacked and pressed with the aid of heat into solid blocks about 2 ft. by $4\frac{1}{2}$ ft. by 6 in. in dimensions. The blocks are then sliced on a planer into sheets ranging in thickness from 0.005 in. to over 1.0 in. The sheets are seasoned to remove the volatile solvents and polished by pressing under heat between polished nickel-plated steel plates. Films and foils are made by casting a dope on a moving polished surface. The volatile solvents are evaporated and the resulting film is stripped from the support, dried and wound into rolls. Films from 0.0005 to 0.010 in. thick can be made by this process.

General characteristics

Cellulose acetate plastics are truly thermoplastic. They are softened by the application of heat and harden again upon cooling. This cycle of softening and hardening may be repeated without any chemical change taking place in the material. The degree of plasticity may be controlled over a wide range by varying the amount and type of plasticizer as well as the characteristics of the basic cellulose acetate itself. The plasticity or flow is thus easily adjusted to that degree which is best suited to the particular method of molding employed and to the particular form, size or shape of the article to be made. In other words the material is custom built for the application.

Mechanical strength and toughness are outstanding characteristics of acetate plastics. Rugged and durable articles can be molded or formed with relatively thin cross sections. Prominent examples are the injection molded oil cans and the great variety of fabricated transparent containers. To mechanical strength is added wear-resistance. Molded steering wheels, window raiser knobs and other automotive hardware retain their initial high polish through long use where other materials fail.

The fine electrical properties of cellulose acetate materials are being widely utilized in the electrical

4—Industrial eye shield made from Plastacele sheet resists flying chips and splinters. 5—Petit ballerina with finely detailed skirt adorns "Gay Whirl" cologne bottles. Gits Molding Corp. mold it of delicate pink Nixonite. 6—Infant garment hanger of pastel Bakelite Cellulose Acetate is injection molded by Earl S. Tupper

industry. Even after soaking in water the electrical resistance is surprisingly high. Thin foil wrapped directly over copper wire offers an ideal insulation for many applications where economical use of space is important. Injection molded parts are also used in many types of electrical equipment.

Unlimited color possibilities are the invaluable tools of the artist and designer. Cellulose acetate plastics may be obtained in transparent, translucent and opaque color in all shades of the spectrum. By mixing of colors all sorts of configurations are possible, many in imitation of products of nature such as mother-of-pearl, tortoise shell and onyx, and others in original fanciful variegations of many hues.

Developments during 1940

Progress has been made in the past year in the development of cellulose acetate of higher acetyl content which has greater resistance to hot water and to warping at high humidities than previous acetates. These materials are being used for toothbrush handles, which has hitherto not been practical, kitchen utensils, bathroom fixtures, radio bezels and coaster sets.

Further improvements have been made in the clarity of acetate materials. With increased warping resistance and higher clarity, interest has been renewed in transparent sheets for aircraft cockpit enclosures, windows, etc. Large quantities of this type material have been produced for the Allied Air forces. In England acetate is finding increased use in aircraft for such applications as fillets, airducts, scoops, fairings, and veneered propeller blades. Another war development in acetate is the gas mask lens, formed from sheet stock or injection molded from powder. These lenses may be made nonfogging without the use of tacky coatings such as gelatin.

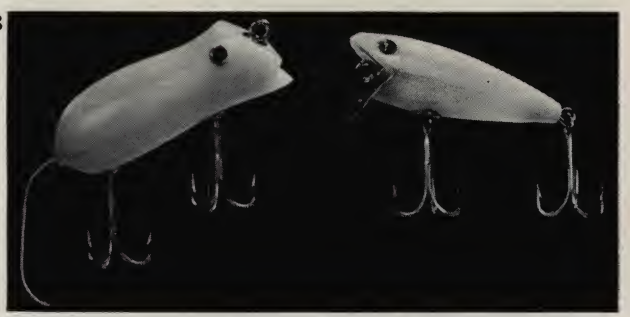
Injection molding continues to move forward with the production of an increasing number of articles which the newer formulations and improvements in machine and mold design have made possible. Among these articles are radio cabinets, tool handles of large cross sectional area such as screw driver and chisel handles, and automobile panels and radio instrument bezels molded with metal inserts.

A recent development with unlimited possibilities, a new type of cellulose acetate sheeting employing very thin translucent louvers or "slats" in white or color has been developed, intended primarily for use in the fluorescent lighting field. The louvers are arranged to control the light and are thin films of opaque colored pigment in suspension within the body of the plastic extending from face to face of the sheet. These parallel lines run through the depth of a clear transparent sheet at right angles to the surface thus combining in large measure the diffusion obtainable with an opal material with the directional efficiency made possible by the use of a clear material. Made with both a smooth surface and an embossed surface for special applications, this acetate sheeting pro-

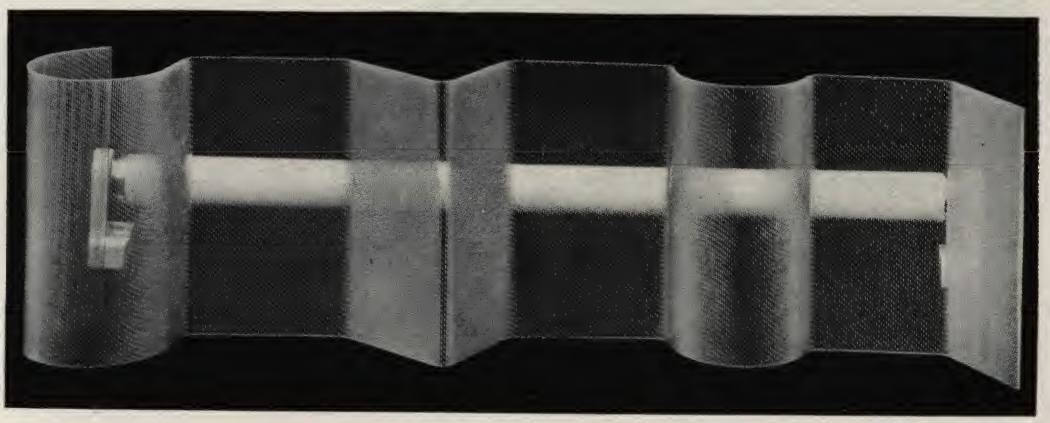
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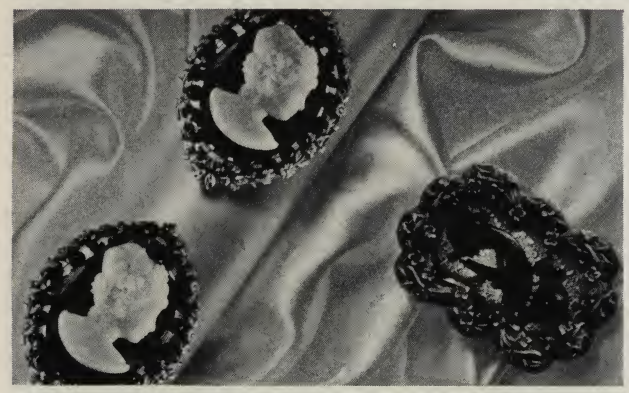
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7—Monsanto Cellulose Acetate embossed sheets because of their light transmitting and diffusing properties are used in Miller Co.'s overhead fluorescent light fixture. 8—This same plastic, molded with a luminous pigment by Cruver Mfg. Co. put Shakespeare Glo-Lite fishing lures on a 24-hour schedule. Exposed to either sunlight or artificial light for a few minutes they will radiate for hours. 9—This piece of "Louverglas" clearly shows through its many contours how it transmits light. Alternate strata of translucent and transparent material fixed in juxtaposition control the rays. One of its first applications has been in the lighting field



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10—Engineering and Research Co. use Lumarith for laminating airplane propellers. The material acts as a good adhesive and is sufficiently stable to atmosphere conditions. 11—Expensive-looking cameos of Tenite designed by Josef of Hollywood and molded by Merrigan Plastics represent the advance of this material into the costume jewelry field. 12—Ramifications of deep drawing cellulose acetate sheets are evidenced in these luminous Lumarith store window display pieces created by J. M. Gordon Company

vides a method of directional control for the continuous linear source of light. Light rays are directed and glare is eliminated. The material is available in several colors.

The extrusion of acetate profile rods has advanced in the past years. A very recent example is extruded strips or webbing for weaving into porch and lawn furniture.

Other new applications for sheet and film stock include shields or covers for fluorescent lamps, animated display signs and three dimensional type displays.

Forms available

Injection molding powder.
Compression molding powder.
Cut sheets in standard sizes 20 in. by 50 in. by any thickness from 0.005 in. to over 1 in.
Films and foils in continuous lengths up to 42 in. wide, in thicknesses from 0.0005 in. to 0.020 in.
Cylindrical and profile extruded rods.
Extruded tubing.

Methods of fabrication

Compression molding at 290–350 deg. F. and 2000 to 5000 lbs. per sq. in. pressure. The material is cooled under pressure to harden. No heat curing is required.

Injection molding in all standard machines.

Mechanical operations such as milling, turning, punching, sawing, drilling, etc. The material machines similarly to soft metals, the same type of tools can be used. Automatic screw machines may also be employed. Parts may be cemented together or joined mechanically by rivets, screws, etc. A high lustrous polish is obtained by buffing wheel or tumbler polishing. Dip polishing or lacquering is also used for many articles.

Dry swaging or drawing: Many containers, covers, watch crystals, etc., are drawn from sheet stock by hot swaging operations.

Typical applications

Automobile steering wheels and hardware.
Business machine keys.
Lamp shades and lighting accessories.
Costume jewelry and watch crystals.
Airplane cockpit enclosures.
Decorative and advertising novelties.
Transparent containers.
Fountain pens and mechanical pencils.
Electrical appliances.
Fish lures and fishing reel parts.
Combs and toilet articles.
Spectacle frames and protective goggles.
Instrument and radio panels, dials and control boards.
Musical instruments

Outstanding properties

Mechanical strength
Transparency
Colorability
Fabricating versatility.
High dielectric strength.
Moldability.

Trade names

Bakelite Cellulose Acetate, Lumarith, Monsanto Cellulose Acetate, Nixonite, Plastacele, Tenite I.



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1—Chrysler's "New Yorker" has injection molded acetobutyrate instrument panel. Door trim strips are extruded from the same material. 2—Gay, weather-resistant terrace furniture is woven from continuous length strips extruded by Detroit Macoid Co. 3—Colorful interior refrigerator parts of this material are unaffected by the cold temperature. 4—Mueller Brass Co. shower heads manufactured in pastel shades throw a "needle" spray of water. The stability of the material is important for this feature. All are of Tenite II

Cellulose acetate butyrate

CELLULOSE acetate butyrate closely resembles cellulose acetate in appearance, properties and uses, so that a complete discussion would be largely a duplication of the article on cellulose acetate. For that reason only the points of difference between the two materials will be treated here.

Chemistry of formation

Cellulose acetate butyrate is made in the same manner as cellulose acetate, using a mixture of butyric and acetic acids and anhydrides. The properties of the resulting product can be varied by altering the relative proportions of the two acids and anhydrides used; the degree of hydrolysis and the viscosity can also be regulated. In general, the mixed ester has greater solubility in a wider range of solvents and is compatible with a greater number of plasticizers than is the straight acetate. Plasticized mixed ester compositions have lower moisture absorption and better weathering resistance, and lacquers made from these compositions have greater adhesion than if made from cellulose acetate.

General characteristics

Molding composition made from cellulose acetate butyrate has excellent dimensional stability. Its low water absorption and low loss of soluble matter during immersion are indicative of its resistance to shrinkage and distortion under varying conditions of temperature and humidity.

Compared with cellulose acetate plastics, injection molding of cellulose acetate butyrate composition requires less pressure than is indicated by the flow designation. Up to a certain point flow increases uniformly with the temperature, but beyond that critical temperature it flows considerably faster. Thus in a small degree it approaches the characteristic of metals with a definite melting point. Because of this fact it is possible to make this material in flows which below the molding

temperature have much greater resistance to heat. It can be supplied in formulas which will resist distortion and impairment of surface luster even when boiled for short periods of time. An outstanding property is the excellence of the weld within the molded piece, resulting, from a practical standpoint, in even greater toughness than is indicated by its relatively high elongation.

As in the case of acetate materials, it is advisable to dry the mixed ester composition just before molding in order to keep flow uniform and to secure the most odorless product. The dried material should be taken directly from the dryer to the molding machine, since it will regain moisture fairly rapidly, particularly under warm humid conditions. Peculiarly, cellulose acetate butyrate molding composition is not compatible with cellulose acetate compositions and the two should never be mixed in molding.

Developments in 1940

The outstanding advance in the fabrication of thermoplastics during the past year has been the development of equipment for continuous extrusion of the molding composition in the form of rods, tubes, strips and special shapes. Heretofore, production in this line has been confined to a few standard sizes of rod and tube made by the plastic manufacturers themselves from paste (composition containing solvent). With the continuous extrusion machines now available, the usual type of molding composition in granular form can be used, making possible the rapid production by custom and private molders of many types of special shapes and sizes in any desired length. This opens a new field which promises to become of increasing importance in the near future.

The appearance of continuously extruded forms of cellulose acetate butyrate composition during the past year has received special attention in fields where molded plastics have not hitherto been considered. Woven strips and rods replacing reed and rattan in outdoor furniture have been given much favorable publicity; the excellent weathering qualities of this plastic, combined with its availability in bright colors, promise revolutionary changes in this industry. Decorative uses for extruded strips in special shapes are seemingly unlimited in both utility and novelty applications.

Forms available

Injection process—granulation or pellets
Compression process—granulation or pellets
blanks cut from molding sheet 0.150 in. to 1 in. thick, up to 20 in. by 25 in. in area.

Methods of fabrication

Molding—by injection
—by compression
—by continuous extrusion

Molded objects can be machined with the same tools as used for wood or metal, care being taken to regulate the speed of the lathe to avoid overheating, in which case the material softens and gums the tools.

Typical applications

Automobile exterior lenses
Toothbrush and shaving brush handles
Refrigerator hardware
Gunstocks and forearms
Radio cases
Register housings
Beer scrapers
Coasters
Furniture

Outstanding properties

Low moisture absorption
High dimensional stability
Excellent weathering resistance
High impact strength
Availability in colors
Improved finish

Trade name

Tenite II

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5—Injection molded Tenite II Silvertone radio escutcheon lacquered on reverse side by "See Deep" process by Erie Resistor Corp. Dimensional characteristics and resistance to lacquer solvents are required qualities here. 6—To withstand rough handling and retain their luster UARCO registers are molded of acetobutyrate by Sinko Tool & Mfg. Co. 7—Arch supports made from this material are strong, odorless, and perspiration-proof. Formed to fit any prescription by National Foot Appliance Laboratory





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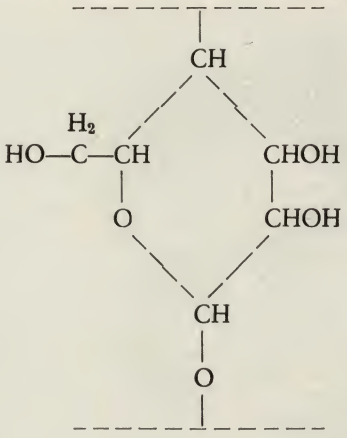
1—Cellulose nitrate the oldest of plastics is continually doing new jobs. The workmen are wrapping a pipe with Pyralin to prevent chemical corrosion from within the soil. 2—Snowy white pearl Celluloid improves the appearance of knives by Imperial Knife Co. Good-looking handles are made from composited stock where several layers of various colors are bonded together. Combinations of pearl on pearl, or pearl on plain colors are popular

Cellulose nitrate

CELLULOSE nitrate, the most venerable member of the chemical plastics field, continues to maintain good volume in its three established uses of explosives, protective coatings, and plastics; although in the last of these three it now finds itself yielding place in poundage to its more vigorous relative, cellulose acetate, on account of the spectacular development of the molding powders made from the latter material.

The history of nitrocellulose and the plastics produced from it have been frequently summarized, the successful industrial use extending from the preparation of the base material by Schönbein, to the plastic work initiated by Parkes and the Hyatts. Since those remote times the improvements, although major, have been mainly in the field of controlling manufacture, controlling viscosity and improving stability, together with a host of practical uses.

GLUCOSIDIC UNIT OF CELLULOSE



Chemistry of the product

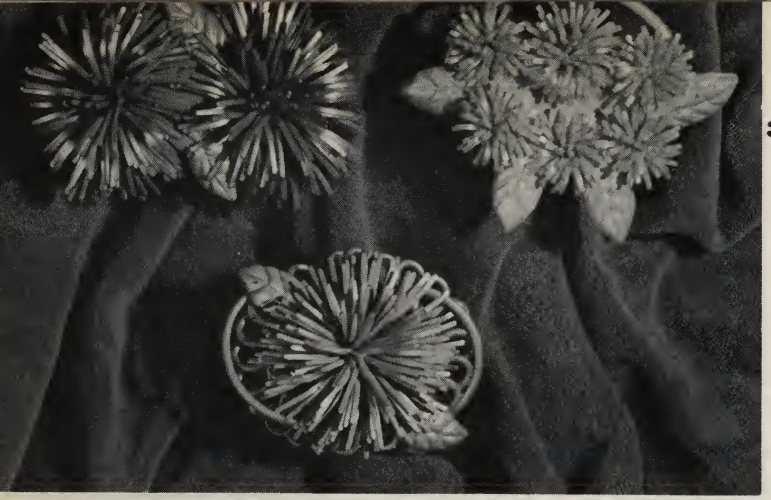
Since the work of Meyer & Mark, the following glucosidic basic structure has been generally accepted for cellulose itself as may be seen in the next column above.

Units of this type are strung together in lengths up to 3,000 to 3,500. Cellulose may, therefore, be considered as a polyhydric alcohol, amenable to the usual reactions of the aliphatic alcohol groups, but limited by the complexity of the molecule and the mechanical difficulties of attacking the fibers (cotton and wood) which are its source.

Cellulose nitrate is usually defined by its nitrogen content and its viscosity. For complete esterification, a nitrogen content of 14.16 percent would be required in the finished product. Actually, nitrogen in cellulose nitrate used for plastics usually ranges from 10.5 to 11.5, with lacquer nitrocotton being nearer to 12 percent nitrogen, and explosive nitrocotton nearer 13 percent.

Viscosity depends on the amount that the cellulose chain has been broken down into shorter units. The greatest degradation occurs in the case of lacquer nitrocellulose, where the viscosity is reduced to 1/4 to 6 seconds as determined in a 12.2 percent solution by the falling ball method. For plastics work, the viscosity is considerably higher.

In manufacture, carefully purified cotton or wood cellulose having a high alpha cellulose content is condi-



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3—Rods of Monsanto Cellulose Nitrate cut to lengths and fabricated into smart costume jewelry. 4—Unbelievable but true, modern corset stays are tipped with Celluloid. 5—High style sun goggles are economically fabricated of the same material by Optical Products Company

tioned to the desired water content and is then treated with a mixture of nitric and sulphuric acid. Controlling factors are the shape and density of the cellulose chips, the relative amounts of nitric acid, sulphuric acid and water, and the time, temperature and agitation of the nitration operation. Spent acid is subsequently drained off, the nitrated material is given prolonged treatments with hot water, bleached, boiled again in water and is finally subjected to the dehydrating operation by which, under hydraulic pressure, the water is largely replaced by alcohol. Viscosity control is usually effected by the nitrating treatment, or by subsequent digestion under heat and pressure; but as an alternative, the cellulose raw material may be degraded before nitration. Fractionation of commercial nitrocellulose into various viscosities has been studied by Spurlin and others. The alcohol-wet nitrocellulose is now ready for incorporation into plastic.

Camphor is still the standard plasticizer for cellulose nitrate, although small admixtures of other materials are occasionally used. The plastic is colloided in masticating mixtures with the plasticizer and solvents, and strained under hydraulic pressure while in soft condition. It is colored and simultaneously freed from solvent by sheeting on rolls, is baked under hydraulic pressure into cakes slightly larger than the standard 20 in. by 50 in. size accepted by the trade, is sheeted and seasoned over a considerable period to remove remaining solvents and is finally press-polished under low heat in hydraulic presses. Alternately, it may be extruded continuously as tubes, rods or sheets.

These laborious operations have been required on account of the susceptibility of the plastic to high temperatures; but by the same token they have permitted a vast range of controlled and decorative effects which would scarcely be feasible by any other means of preparation.

General characteristics

Cellulose nitrate plastics have found favor because of their great toughness, water-resistance and ability to be shaped with ease, and also because of their availability in a wide variety of solid and patterned colors, transparent, translucent and opaque.

During the last few years refinements of treating to remove last traces of sulphate have resulted in a surprising stability. Flammability has been the main drawback, although this has been considerably reduced by special plasticizers containing chlorine and phosphate as fire retardants. The plastic continues to be the favorite base for fountain pens because of its resistance to the chemicals involved; toothbrush handles on account of its toughness and beauty; drawing instruments, unbreakable watch-crystals on account of its clarity and water resistance; and a wide range of other similar uses from wood heel coverings and piano keys to dominoes.

In the protective coating field, cellulose nitrate continues to be the major constituent for conferring toughness, long protection and quick drying at room temperatures or slightly above. It finds extensive use in artificial leather, adhesives and emulsions for coating of paper.

Since cellulose nitrate and its plastics have been so thoroughly investigated and exploited over a period of years, it is not unusual that there have been no startling developments during the past year.

Mention might be made of the extension of the use of this plastic as a wrapper for pipe lines and in the

preparation of cartoon movies by Disney, Fleischer and many of the others.

Although cellulose nitrate is one of the oldest plastics it continues to maintain its important place as one of the important raw materials. Newer types have supplanted in some places such as the safety glass field but elsewhere as in the fountain pen and pencil industry it still maintains its preeminent position where a wide variety of different color effects are obtainable. In the form of rods it continues to be used for making novelty buttons.

Forms available

Lacquers
Emulsions
Plastic rods
Plastic tubes
Plastic sheets in various thicknesses (20 in. by 50 in. standard)
Color chips
All in great variety of colors and patterns.

Methods of fabrication

Cutting
Sawing
Punching
Drilling
Drawing
Turning
Printing
Embossing
Polishing
Swaging

Molding, by heating at 160 deg. F.–220 deg. F. and pressing (mechanical or hydraulic)
Blowing, by placing softened sheets of the material in mold and forcing air between them.

Typical applications of plastic

Bag frames
Belting interliner
Blotters and Calendars
Brushes
Buckles
Clock dials & crystals
Cutlery handles
Dominoes
Drafting instruments
Eyeshades
Fountain pens
Golf club parts
Spectacle frames
Index forms
Labels
Mirrors and Toys
Novelties
Piano keys
Pencils and Rulers
Razor handles
Shoe eyelets & lace tips
Toilet seats
Tool handles
Toothbrush handles
Wood heel covers
Pipe line wrappings

Outstanding properties

Toughness
Water resistance
Ease of fabrication
Ease of cementing
Clarity
Colorability
Flammability

Trade names

Amerith, *Celluloid*, *Monsanto Cellulose Nitrate*, *Nixonoid*, *Pyralin*.

6—Radio dials and drafting instruments of Nixon Cellulose Nitrate sheet stock are stable in normal climatic conditions. 7—Scuff-proof, long-wearing wood heels are coated with either plain or embossed colored Pyralin sheet to match leathers. 8—Foremost market for fancy pattern cellulose nitrate tube stock is pen and pencil barrels. This Pilgrim set by Le Boeuf Pen Co. is of Monsanto Cellulose Nitrate in a chevron design

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1—Multi-colored Ethocel strips are woven into sturdy terrace furniture by Pierce Plastics, Inc., for Ficks Reed Co. 2—Feather-weight, tough Ethocel sheet form is fabricated by Browne Engineering Co. for premium use cigaret package covers

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Ethylcellulose

CELLULOSE derivatives, particularly the esters such as the nitrate and the acetate, have long been utilized in the fields of plastics and protective coatings because they possess the properties of toughness and thermoplasticity. Ethylcellulose is a comparatively new cellulose ether which recently has been made available commercially in this country. It possesses to an unusual degree the properties of toughness and thermoplasticity, a low order of flammability, and has formulation flexibility. This combination of properties has stimulated a widespread interest in its use.

Chemistry of formation

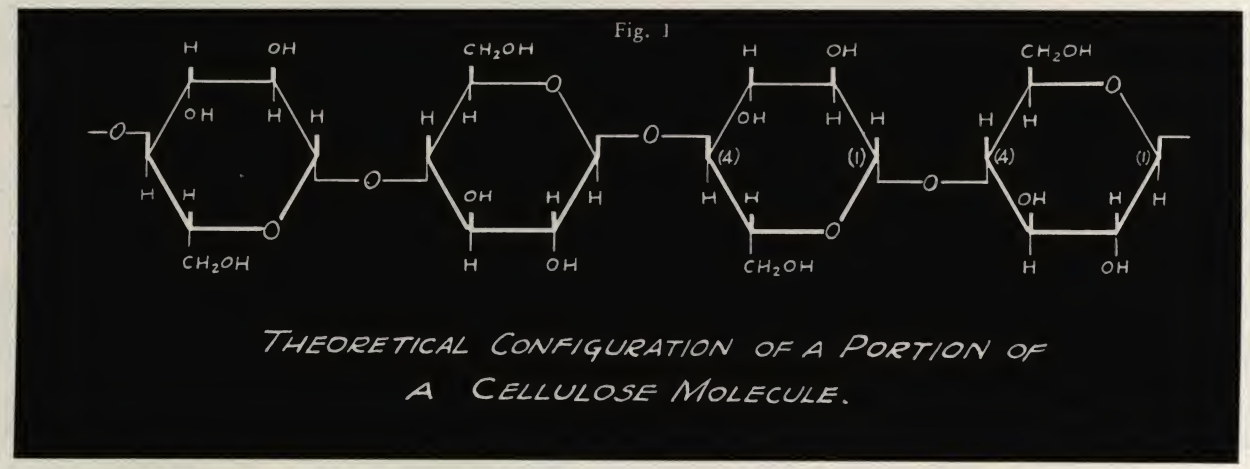
Cellulose is conceived to be composed of long chain molecules, the building units of which are glucose residues having the empirical formula $C_6H_{10}O_5$. Each such unit has three available hydroxyl groups which can be substituted. Fig. 1 shows the configuration of a group of four of these theoretical units. Ethylcellulose is a cellulose ether in which ethyl groups have replaced the hydrogens in the hydroxyl groups of the glucose residues. The standard ethylcellulose available commercially has been substituted to the extent of 2.4 to 2.5 ethoxyl groups per glucose residue.

It is prepared by treating cellulose, such as wood pulp or cotton linters, with a strong aqueous solution of sodium hydroxide. This causes the formation of alkali cellulose which is then alkylated with such reagents as ethyl chloride or sulfate. The operating conditions are carefully controlled in order to prevent undesirable degradation of the cellulose and destruction of the alkylating agent. After etherification is complete, the excess reagents are removed by washing and distillation. Ethylcellulose is easily purified by washing the product free from soluble materials.

General characteristics

Ethylcellulose containing 2.4 to 2.5 ethoxyl groups, and within this range of substitution material of 47 to 48 percent ethoxyl content, possesses the widest variety

Fig. 1


H
OH
CH₂OH
O
OH
H
H
H

of useful properties. The properties of unusual toughness coupled with thermoplasticity and low flammability have been mentioned above. The unplasticized material is flexible at temperatures as low as −40 deg. C., and it is very extensible. Because of these facts, ethylcellulose compositions possess a degree of low temperature toughness not found in other thermoplastic materials. It burns about like cellulose acetate and the products of combustion are harmless gases. The maximum advantage can be realized from the thermoplastic character of ethylcellulose because it is also stable to heat. Its inertness to alkalies of all strengths could be deduced from its ether structure; likewise, its solubility and compatibility with a wide variety of solvents, resins, waxes, oils and plasticizers could be predicted. It has a moisture absorption of 2 percent which is somewhat better than cellulose acetate and slightly poorer than nitrocellulose. Bass and Goggin[1] have shown that ethylcellulose film and molded plastics are excellent electrical insulating materials.

The specific gravity of 1.14 for ethylcellulose compares with 1.37 for cellulose acetate and 1.65 for nitrocellulose. This low value has special significance because it means that 1 lb. of ethylcellulose will produce as many plastic articles as 1.20 lbs. of cellulose acetate and 1.40 lbs. of nitrocellulose. This same advantage holds for films, protective coatings, adhesives, etc.

Straight chain petroleum hydrocarbons comprise the only class of organic liquids which do not exhibit marked solvent action on ethylcellulose. An exceptionally good solvent combination, which is also economical, is composed of 70 to 80 parts by weight of an aromatic hydrocarbon, such as toluene, or a hydrogenated naphtha, such as Solvesso, with 30 to 20 parts by weight of an aliphatic alcohol, such as denatured ethyl alcohol. The available plasticizing agents are practically unlimited and cover such widely divergent classes as high boiling esters, raw oils, air-blown oils, fatty acids and chlorinated diphenyl derivatives. Heat-bodied oils usually are considered as incompatible but can be used in limited quantities, especially in the presence of a mutually compatible third ingredient. Useful waxes include the usual ester type waxes, both vegetable and animal, and many bituminous materials such as montan wax, coal-tar, stearin pitch, etc. Paraffin in the presence of a mutually compatible third ingredient can be used in appreciable quantities, but alone it is incompatible with ethylcellulose. Compatible resin classes encompass many of the natural resins including all of the alcohol soluble types, pure phenolics, rosin modified phenolics, rosin modified maleates, long oil or fatty acid extended alkyd resins and some miscellaneous types such as ester gum. Many hydrocarbon, urea-formaldehyde, short oil-modified alkyd and oil-modified phenolic resins exhibit limited compatibility, but are quite useful in ethylcellulose compositions in which the amount of resin employed is relatively low. Again, the principle of employing a mutually compatible third ingredient, such as a plasticizing agent, is often effective in overcoming the tendency for incompatible mixtures to form.

Ethylcellulose dissolves readily in hot resins, oils, waxes, plasticizers and mixtures of these in the absence of any volatile solvent. Since such compositions are very thermoplastic, they can be applied as molten mixtures at elevated temperatures and form the bases for adhesives, coatings and the like.

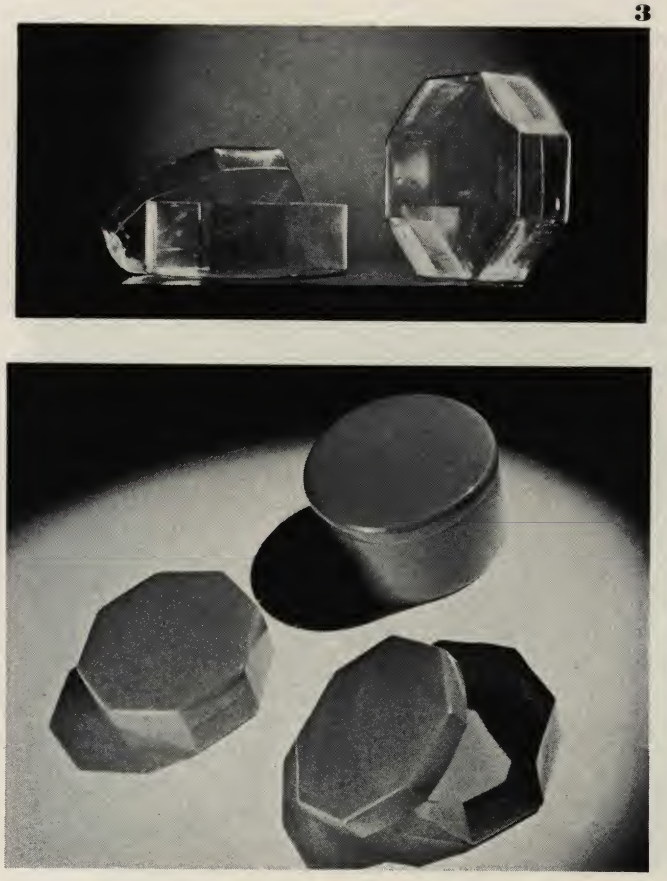
Developments during 1940

The suitability of ethylcellulose for use in plastics was discussed in an article by Wiggam[2] in the October 1936 issue of Modern Plastics. In the October 1937 issue, Gibb[3] discussed some ethylcellulose plastics and the general method of preparing them. These earlier articles were confined to mixtures of ethylcellulose and plasticizers. Wiggam and Koch[4] brought out the effect of adding resins in ethylcellulose plastic composition.

Considerable progress has been made in the application of ethylcellulose plastics by extrusion processes as a coating for wire over the past two years. In this case,

3—Rigid containers in round and octagonal shapes illustrate the deep drawing possibilities of ethylcellulose sheeting. Square, hexagonal and irregular shapes in both transparent and opaque materials can be readily drawn to required depth

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[1] Shailer L. Bass and W. C. Goggin, Transactions of The Electrochemical Society Vol. LXXIV, pp. 47–65, October 13, 1938.
[2] D. R. Wiggam, Modern Plastics, p. 31, October 1936.
[3] D. A. Gibb, ibid., p. 23, October 1937.
[4] D. R. Wiggam and William Koch, ibid., p. 28, October 1938.

ethylcellulose is combined with plasticizer alone to give compositions that are quite tough over a wide range of temperature. In practice, it has been found that the conditions of application from the standpoint of temperature control are quite important in the production of the most useful coatings.

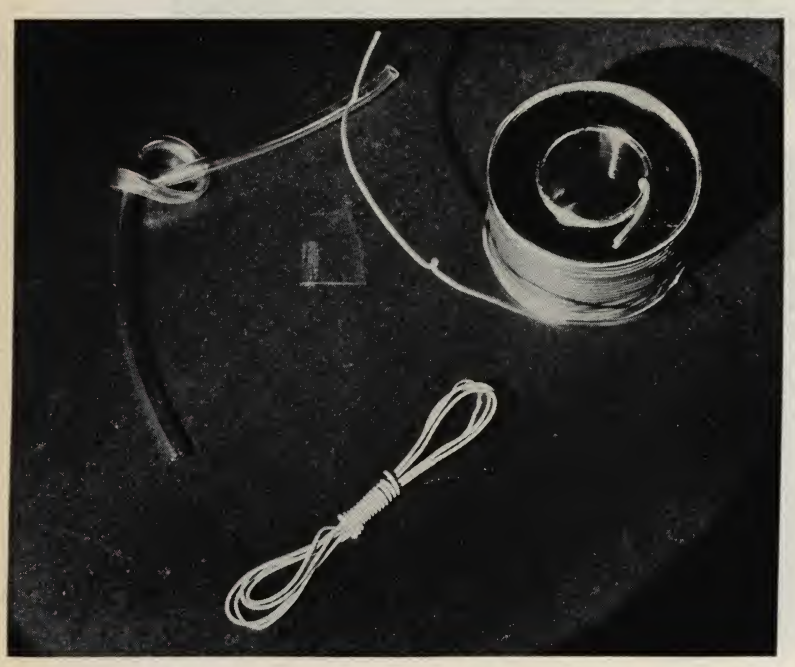
Ethylcellulose plastics are likewise being used for the extrusion of strips for the manufacture of modern furniture. In this case the strips take the place of reeds or canes formerly employed, and because of the wide possibilities for bright colorings, the finished furniture is very attractive. The color stability of ethylcellulose plastics is unusually good, which is a factor of considerable importance in furniture.

Within the last half year, a new transparent ethylcellulose sheet material has become available for use in the fabrication of transparent rigid containers. The material possesses a number of unique properties which readily adapt it to the mass production of such containers, particularly when used in gages over 0.003 in. and as heavy as 0.020 in. Particularly noteworthy are the flexibility, toughness, dimensional stability, low moisture absorption, ease of fabrication and of printing. It may be deep drawn by means of a plunger to a substantial depth often into round, hexagonal, square and irregular shapes. The material is drawn well below its softening point of 310 deg. F. or its melting point of 375 deg. F. so the drawn sheet retains the original luster, color and strength of the flat sheet. No heating or soaking is required before such operations.

Ethylcellulose sheeting may be fabricated by solvent or lacquer type adhesive, either at normal or elevated temperatures, providing that the solubility of the material in organic solvents is considered.

There is increasing use of ethylcellulose plastics for injection molding. Practically all colors can be made and the product is found to inject under the same conditions as cellulose acetate molding powders. Finished plastics are tough over a wide temperature range, they are unusually water resistant and have excellent dimensional stability. This latter is due to the fact that less volatile plasticizer is used in the fabrication of ethylcellulose plastics and in certain cases appreciable amounts of non-volatile resins may be used.

4—Used for insulating wire, extruded ethylcellulose, formulated by proper plasticization will not crack and resists the tendency of wire to cut through insulation under high temperature usage. (Photo, courtesy Hercules Powder Co. Inc.)



Forms available

Ethylcellulose is available in a variety of ethoxyl contents and viscosities as shown in the following table.

Types	*Viscosity Grades*
T—48.5–50% ethoxyl content	Each of the different types are offered in widely varying viscosities
N—46.8–48.5% " "	
K—45.5–46.8% " "	
G—44.5–45.5% " "	
D—43.5–44.5% " "	

Methods of fabrication

Ethylcellulose plastics may be prepared either with or without solvent. If solvent is employed, the ordinary process of mixing, followed by sheeting, drying and granulation, is used. Ethylcellulose may likewise be compounded on a heated two roll mill or in a mixer of the Banbury type without the use of volatile solvents. In this process seasoning is avoided and there is very little stock in process at any one time. The process is not suited, however, to the production of the most delicate tints, as the temperatures employed result in some darkening. For the heavier pigmented plastics, this process may be successfully used.

Typical applications

Protective coatings
Adhesives
Pigment grinding base
Rigid containers and boxes
Extrusion wire insulation
Injection plastics
Cable lacquers extended
ships for furniture
Hot-melt paper and cloth coatings

Outstanding properties

Unusually good low temperature flexibility and toughness
Wide range of compatibility
Stability to heat
Thermoplasticity
Electrical resistance

Trade names

Dow Ethocel, Dow Ethofoil, Hercules Ethylcellulose.



1



2

1—Methyl methacrylate dentures comprise the desirable qualities of moldability, strength, durability and stability. They are compatible with oral conditions and are easily cleaned. 2—Both Crystalite and Lucite are injection molded by Tech-Art Plastics to produce these 3 in. high sign letters for Colorvision Ads, Inc. They are assembled into all kinds and types of electrical advertising signs

Acrylic resins

THE resinous products obtained by the polymerization of the monomeric derivatives of acrylic acid are known as the acrylic resins. This group includes acrylic and methacrylic acids, their esters, amides, salts, halides, and nitriles. From a commercial standpoint the esters are of most importance at the present time. Several investigators experimented with acrylic acid derivatives prior to 1900, but the industrial development of these resins was due mainly to the research of Dr. Otto Röhm, of Darmstadt, Germany, whose original publication on this subject appeared in 1901. In 1931 acrylic resins were first made available in commercial quantities in this country.

Chemistry of their formation

The structural formula of acrylic acid is $CH_2{=}CH{-}COOH$ and that of its widely used alpha-methyl derivative (methacrylic acid) is $CH_2{=}C(CH_3){-}COOH$. The reactions involved in the synthesis of acrylic acid esters, starting with ethylene chlorohydrin, may be represented as follows:

1. $CH_2OH.CH_2Cl + NaCN \rightarrow CH_2OH.CH_2CN + NaCl$
2. $CH_2OH.CH_2CN + ROH + H_2SO_4 \rightarrow CH_2{=}CH{-}COOR + NH_4HSO_4$

Esters of methacrylic acid are conveniently prepared by converting acetone cyanohydrin into alpha-hydroxyisobutyric acid esters and dehydrating the hydroxy ester. The esters of both acrylic and methacrylic acids polymerize under the influence of heat, light, oxygen, and oxygen-yielding substances, for example, sodium peroxide, hydrogen peroxide, and benzoyl peroxide. The mechanism of the polymerization of polyacrylates is believed to be similar to that of other compounds containing vinyl groups. The usual conception of the structure of these resins is that they exist as chains of various lengths formed by the linking together of the original monomeric molecules.

General characteristics

The various acrylic resins range from soft, sticky, semi-liquids to hard, tough, thermoplastic solids, of which the latter are the ones chiefly useful in plastics. With the softer members of the series, the use of plasticizer is, in general, unnecessary and undesirable. Polymethyl methacrylate, which is of the hard type, is made commercially both without and with plasticizer, to meet various requirements of fabrication and use.

The compatibility of these resins with other synthetic polymers and with natural resins is limited. Many of the acrylic polymers are rather unexpectedly incompatible with each other. However, desirable variations in the properties of these resins can be achieved by copolymerization of the various monomers.

Acrylic resins as binders for wood, metals, textiles, rubber, glass, and other materials offer the advantages of freedom from bacterial and fungous deterioration, and afford the possibility of a colorless transparent bond. The elasticity and extensibility of the acrylic adhesives permit their use where the bonded assemblies are subject to flexure and elongation. (*Please turn next page*)



3

In the textile field, aqueous dispersions of the acrylic polymers are used as permanent finishes, stiffening and increasing the tensile strength and wear resistance of the impregnated fabrics. They do not require baking, are wash fast, and give stiffness and sheerness to a fabric. The acrylic resins are also widely used as coatings for metal and finishes for leather.

A denture material made of this type of resin has met with a very favorable reception in the dental profession. In addition to being readily pigmented to simulate the color of the mouth tissues and possessing the necessary toughness and resistance to water, acids and alkalies, the temperature range in which it can be satisfactorily formed in the plaster molds employed in the dental laboratories is not as restricted as it is for the other synthetic resins in current use for the same purpose.

The most important of the acrylic resins used in making cast sheets is polymethyl methacrylate. The aircraft industry has found these sheets particularly well adapted to its requirements, because of their lightness, weathering resistance, and clarity, and therefore employs them in landing light covers, gun turrets, and cockpit enclosures in addition to the more common windshield and window applications.

Since the basic resin is crystal clear, it is possible by adding pigments and dyes to produce colored molding powder ranging in color from very delicate tints to deep shades and novel frosted effects.

Development during 1940

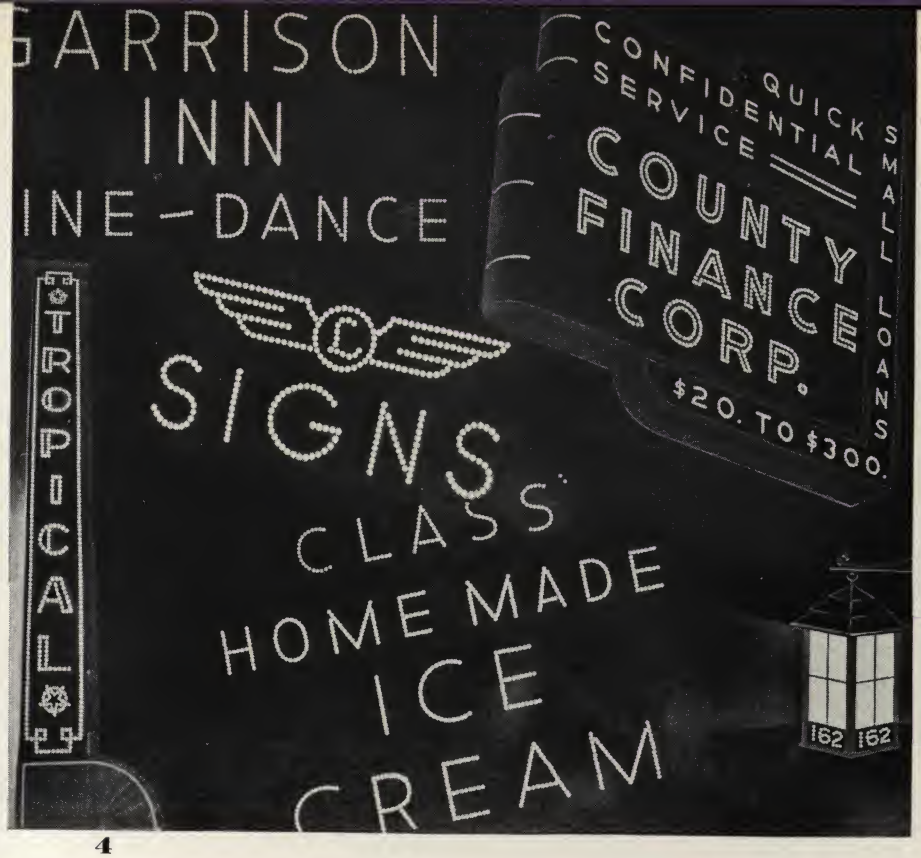
During 1940 the acrylics have been in increased demand in the aircraft industry wherever wider use is being made of large transparent sections. The year also saw increased use of the acrylics in the display field especially for store and counter fixtures. Machinery windows and other industrial applications also consumed larger quantities of the material than in previous years.

One of the more important new developments was the fabrication of whole pieces of furniture from cast sheets. The highlights of a New York manufacturer's spring exhibition were several rooms completely furnished with acrylic furniture. The beauty, strength and crystal clarity of the acrylics were used to excellent advantage in sturdy, stain-proof chairs, beds, tables, lamps, dressers, cabinets, and settees, following modified classic designs. Other manufacturers are using the materials for handles and decorative trim.

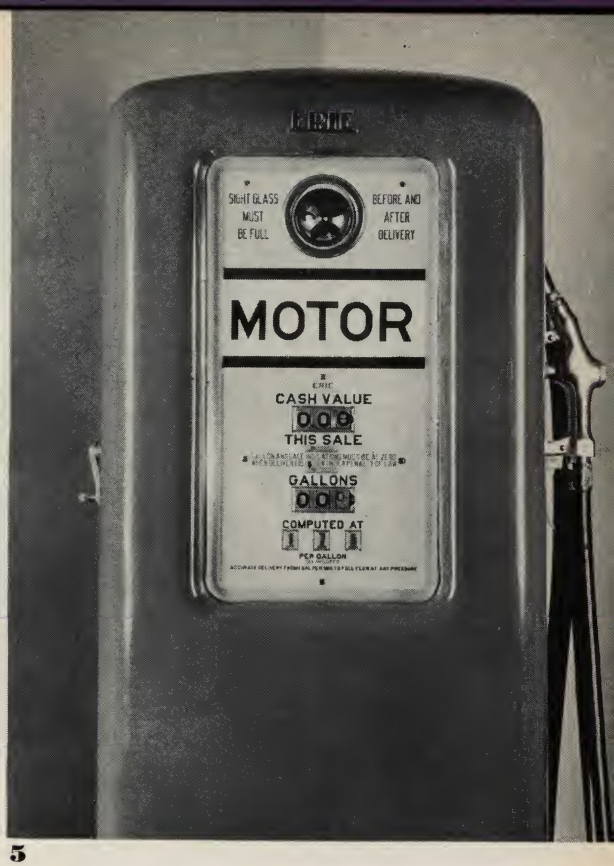
A major technical development has been the production of molding powders with improved molding characteristics. For example, while cast acrylic sheets have been widely used for brush backs, molding of these pieces had formerly been considered impractical. In 1940, however, a leading manufacturer was able to injection mold a whole line of acrylic brush backs—some of them more than $^1/_2$ in. in section. Another injection molder was able to produce a radio dial more than 56 sq. in. in projected area. A hair dryer part weighing more than 1 lb. 10 oz.—one of the largest thermoplastic moldings ever produced—was compression molded in acrylic powders during 1940.

The unlimited color possibilities of the acrylics was convincingly proved with the development of special jewel colors rivaling the genuine in depth and sparkle. Molded jewels were widely used for costume jewelry and, while the crystal-clear powders retained their popularity, modifications of these colors were effectively used for cosmetic containers, cigaret cases, and similar decorative applications.

The automotive industry became the principal consumer of acrylic molding powders during 1940, when more than 38 different acrylic moldings were used in 13 makes of automobiles. Dials and clock faces, the markings of which are molded into the piece and illuminated from one edge, are proving their practicability



4



5

6



3—Plexiglas sheets clear, and less fragile than glass, are used for the cockpit and nose of this Consolidated Aircraft Model 29-4 engine flying boat—an important outlet for stock of this type. **4**—Lenses fabricated from Lucite rods give unusual brilliance and variety to display signs. **5**—Large dial frame, numeral lenses and gasoline name plate are injection molded from Lucite by Erie Resistor Corp. Edge lighting qualities "pipe" the light over the entire area. **6**—Huge, transparent circular Crystalite pieces put a new front on the Vue-Gene hair dryer. Molded by General Electric Co. **7**—Production furniture and fittings in this modern Glassic bedroom by Grosfeld House are fabricated from thick sections of Plexiglas sheets or rods. **8**—Carved Lucite mural in the back bar of an illuminated West Coast cocktail lounge shows the unique effects secured through edge lighting

8



7





9



10

9—Thomas Mason Co. injection mold exclusively designed containers of clear Crystalite for Saks Fifth Avenue's line of Celares cosmetics. 10—Web-Cel laboratory dialyser fabricated from Lucite sheets and tubes. Used in the recovery of soluble salts or acids from colloidal dispersions, the transparent unit allows continuous inspection and is unaffected by the chemicals

in several 1941 models. In addition, several manufacturers took advantage of the exceptional weather resistances of the acrylics and molded radiator ornaments of this crystal-clear material.

Another outstanding development has been the use of molded methyl methacrylate lenses or small buttons which are used for highway reflector signs and for portable highway flares. An important development in highway safety, these reflectors pick up the reflected beams cast by approaching headlights, and warn of dangers along the road. Trucks and cars parked along the highway at night find the portable highway flares remarkably effective in preventing accidents due to fires which frequently occurred with the use of ordinary torches and burning flares.

Methyl methacrylate dentures have been so well received that they have replaced practically all other plastics for this purpose. Rubber continues to be used only because of its low cost.

Cast polymethyl methacrylate of high softening temperature, capable of being immersed in boiling water without distorting is available for making surgical instruments and accessories which can be sterilized.

Methods of fabrication

Casting: Monomers are mobile liquids which polymerize upon heating in the presence of a catalyst.

Molding: Compression molding conditions are 285 deg. to 360 deg. F. and 1500 to 5000 lbs. per sq. in. The resins are thermoplastic and hence require chilling in the mold. Injection molding conditions are 325 deg. to 425 deg. F. and 3000 to 30,000 lbs. per sq. inch.

Forming: Sheets, bars, and rods may be shaped to specifications at temperatures of about 180 deg. to 250 deg. F., using simple forms.

Machining: The hard cast resins are readily shaped by any of the ordinary operations of machining, and thereafter are polished by application of progressively finer abrasives.

Forms available

Cast sheets up to $2^1/_2$ in. thick and up to 45 in. by 65 in. in plane and formed shapes
Compression molding powder
Injection molding powder
Cast and extruded rods
Granular solids
Solutions in organic solvents
Aqueous emulsions

Typical applications

Airplane windshields
Lenses
Dentures
Brush backs
Containers
Sculptured pieces
Illuminating instruments (medical, surgical, industrial)
Decorative articles
Radiator ornaments
Laminated glass interlayer
Adhesives and protective coatings
Transparent working models and mechanisms
Displays and illuminated signs
Pipe stems
Artificial jewels
Dials and gage glasses
Furniture
Architecture

Outstanding properties

Superior transparency
Permanence of dimensions
Edge-lighting
Colorability
Water resistance
Rigidity
Weather resistance

Trade names

Acryloid, Crystalite, Lucite, Plexiglas.

Alkyd resins

THE alkyd resins have, as principal reacting ingredients, polyhydric alcohols and polybasic acids. The prefix "AL-" from the word "alcohol," and the suffix "-CID" from the word "acid," through an evolutionary process induced by simpler spelling and more euphonious sounding, are the roots of the word *Alkyd*. The name includes the unmodified resins as well as those modified with fatty acids of vegetable oils, with rosin, and with other synthetic resins. The principal alkyd resins on the market are those of the drying type used as complete synthetic finish vehicles all by themselves, and the resins used in lacquers with cellulose derivatives which usually are of the non-drying type. Berzelius reported a resin from tartaric acid and glycerol in 1847, but it was not until 1901 that Watson Smith, seeking a dye, discovered that a resin resulted from fusing phthalic anhydride and glycerol. Modified alkyd resins consisting of mixed esters of rosin, vegetable oil fatty acids, and plasticizing oils such as castor oil, interesterified with polyhydric alcohols and polybasic acids, were disclosed by Arsem, Friedberg, Howell, and Dawson, during 1912–1915. The enormous decrease in cost of phthalic anhydride by the process of Gibbs and Conover of the U. S. Department of Agriculture, who dedicated the patent to the people of the United States in 1918, made possible the commercial success of the alkyd resins. The alkyds modified with phenol-formaldehyde condensation products, as described by Dr. Herbert Hoenel, were among the first really commercially successful products because of the improved water-resistance.

Chemical reactions involved

The reactions of glycerol and of ethylene glycol with phthalic anhydride, as early shown by Kienle and the author, involve principally esterification, and may be represented according to a general reaction:

$$R(COOH)_m + R'(OH)_n \rightleftarrows \underset{\text{(resin)}}{R(COO)_mR'} + \underset{\text{(water vapor)}}{n\ H_2O}$$

If the water vapor is allowed to escape, the equilibrium shifts to the right and the reaction proceeds. Functionality of the reacting ingredients plays an all-important part in determining the properties of the resinous product; the greater the number of reactive points on each molecule that may be seized upon by reactive groups of other molecules, the greater the chance of formation of complex structures, and of gelation. The introduction of modifying monobasic fatty or resinous acids or of monohydric alcohols cuts down the number of reactive functional groups which are available for forming cross-linkages between linear polymeric structures; this decreases the chances of gelation, and introduces different solubility characteristics.

General characteristics

Alkyd resins may be prepared in various ranges of consistency from oily air-drying or non-drying liquid resins of low viscosity right up to high melting point, brittle resins which are used in sanding lacquers and sealers for furniture finishes. The introduction of modifying in-



Alkyd resins incorporated in the surface coating material used by Plymouth further assures the permanence of its high luster finish and also contribute to the accelerated drying rate

gredients into alkyd resins gives them an internal plasticization, because the plasticizing structure is formed as an integral part of the resin molecules "in situ" and may eliminate to a large extent the disadvantages of the use of an ordinary chemical plasticizer, which may be lost by evaporation, oxidation, migration, or absorption.

The compatibility of alkyd resins with other materials commonly used in the paint, varnish, lacquer, and printing ink industries is exceedingly great. There are very few materials with which alkyd resins cannot be made miscible upon judicious formulation. Co-condensation of alkyd resins with other types of resins, such as the phenol-aldehyde and the urea-aldehyde resins, produces many desirable changes in properties, the phenolic modification introducing greater water-resistance, and the urea modification inducing great hardness without sacrifice in color.

Alkyd resins as coatings for metal, wood, and general materials of construction have the advantages of high gloss, good adhesion, and resistance to weathering on exterior exposure. On account of their well-known good properties as long-life protection of the surface, the alkyd resin is king of all the coating materials of the present day, being used in primers, surfacers, colored enamels, white high-baking refrigerator enamels, air-drying brushing enamels, particularly where color is important, in furniture finishes, and in water emulsion paints. The universal satisfaction obtained where protection and retention of original good appearance is desired, together with reasonable cost, has earned for alkyds their enviable place in the finishing industry.

Alkyd resins, up to the present time, have not been important in molding plastics principally because of the fact that their flow under pressure has been too much instead of too little, and the fact that hot strength of such molded compounds is decidedly inferior. However, it is expected that alkyd resins will eventually play an important part in the molded plastics industry.

Recent developments

Aside from the general improvement which takes place year by year in the multifold uses for which alkyd resins are already in use, some of the main new developments of alkyd resins during the past year are, briefly: faster printing inks, better exterior white brushing enamels, alkyd resin emulsion paints, and super-white enamels in combination of the alkyd with urea-formaldehyde condensation products.

The printing industry demands vehicles which will not become sticky on the rolls, but which will set immediately when on the object to be printed. Many new alkyd resins have assisted greatly in solving this problem of the printers.

Vehicles for better white brushing enamels for exterior purposes have been developed which have high gloss, durability, and unsurpassed color retention.

Alkyd resins in emulsion paints are believed to be one of the outstanding developments in coating materials. Water paints of drying oils have been known for centuries, and so have casein paints. Furthermore, the durability of the alkyd resins is accepted as the standard for any coating. But it is only very recently that the natural outcome has been fulfilled by the emulsification of phthalic-glyceride-linseed esters into an alkaline aqueous phase which has replaced the linseed glyceride ester which occurs in nature. The result is a fast-drying water paint which has exterior durability and retention of good appearance at a very reasonable cost with elimination of fire hazard by eliminating the solvent. Furthermore, it is not necessary to wait for wood, brick, or concrete to dry out thoroughly after a rainstorm before painting them.

Glossy, super-hard, super-grease-resistant, white refrigerator finishes, obtained by short baking schedules, are the result of successful combinations of urea-formaldehyde resins with the alkyd resins. There is a versatility of the form of alkyd resins available; there is a resin for practically every type of coating application.

Forms available

Oily, viscous, drying-type resins
Oily, viscous, non-drying-type resin-plasticizers
Air-drying resins in solution form
Non-drying resins in solution form
Soft, sticky resins without solvent
Hard, brittle resins without solvent
Resins in aqueous emulsion form

Methods of application

Spraying
Dipping
Roll coating
Brushing
Hot melt application

Typical applications

Printing ink
Trim and trellis paint
Resinous plasticizers for other materials
Sanding lacquers
Furniture finishes
Original finish for automobiles and tractors
Automotive refinishing
Metal primers and surfacers
Tin decorating enamels
Wrinkle finishes
Water emulsion paints

Outstanding properties

Long retention of initial good appearance
Long exterior exposure life on weathering
Ease of application
Solubility in relatively cheap solvents
High gloss
Adhesion to metal
Quick drying schedule or baking schedule

Trade names

Amberlac, *Aquaplex*, *Beckosol*, *Dulux*, *Duraplex*, *Esterol*, *Glyptal*, *Lewisol*, *Makalot*, *Mirasol*, *Paraplex*, *Rauzone*, *Rezyl*, *Teglac*.



1

1—Highly plasticized Vinylite sheeting contributes to the elegance of the Tourneur Beauty Salon. It is used as sofa upholstery, woven into chair seats, covers the make-up bar top, lines drawers and performs a variety of versatile tasks. The clear material is long-wearing and resistant to oils, lotions and cosmetics

Vinyl ester resins

POLYVINYL esters have gained an established importance among thermoplastics. Applications are now well diversified, and their use in the form of sheet materials, surface coatings, adhesives and molding compounds has been standardized for a number of large-volume articles. Several new modifications of these resins have also been well accepted by industry. Polyvinyl resins are synthetic organic plastics derived from compounds having the vinyl (—CH=CH_2) group. They were known in the laboratory for some years. Production facilities have been so increased recently, however, that polyvinyl esters are now produced at markedly lower costs than even a few years ago. Most important among these resins are polyvinyl acetate, polyvinyl chloride and copolymers of the monomeric esters which combine the best features of each. All these polyvinyl ester resins are thermoplastic in nature. No chemical change takes place in molding and the resins can be reshaped by the application of heat.

Chemistry of their formation

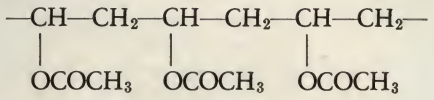
Vinyl acetate is a clear liquid, having a boiling point of 73 deg. C., and the following structure:

$$\begin{array}{l} CH{=}CH_2 \\ | \\ OCOCH_3 \end{array}$$

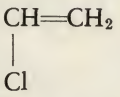
Monomeric vinyl acetate is introduced into an autoclave, a catalyst and a solvent are added, some heat is applied and, after an induction period, the polymerization starts and proceeds until the predesignated limit is reached. The unreacted monomer is then stripped, the polymer is further dried, ground and then packaged.

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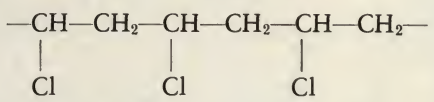
The monomeric ester, when polymerized, forms a linear-chain compound, a portion of which can be shown as follows:



Vinyl chloride is a gas under normal conditions and has a boiling point of −14 deg. C. Its structure is:

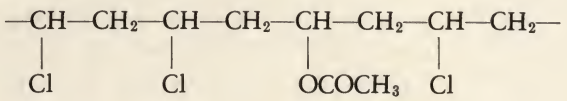


When polymerized in an autoclave, a linear-chain compound is formed as follows:



This resin is always plasticized for use. When compounded and plasticized, it becomes suitable for extrusion and molding compounds and for sheeting. When plasticized and dissolved in a suitable solvent, it results in formulations useful for coating cloth or for stop-off lacquers for electroplating equipment.

Copolymers. If monomeric vinyl chloride and vinyl acetate are mixed together and with a solvent and catalyst, prior to polymerization, then polymerized somewhat in the manner of polymerizing polyvinyl acetate described above, the result is a copolymer, in which, theoretically, the two materials react with themselves and with each other at the double bonds. The structure of this conjoint polymer probably approximates:



In such a copolymer, the chloride: acetate ratio can be varied over a wide range to produce resins of grades suitable for specific applications. Most of the important copolymers at present, however, are in the range of 80 to 95 percent chloride.

The properties of these polyvinyl ester resins are also closely associated with the resin's average molecular weight and with the relative quantities of the polymer bands of which the resin is composed. For each ester type, the tensile and impact strengths, abrasion resistance and viscosity in solution increase with higher molecular weights, while water absorption, refractive index, hardness and electrical properties remain practically constant. Solubility in organic solvents decreases with increase in molecular weight.

To suit best the requirements of individual applications, copolymers of vinyl chloride and vinyl acetate are made whose average molecular weight is a definite value within the range of 9000 (for surface coating resin) to 22,000 (for textile fibers). Intermediate values, as typical examples, are 10,000 for resins to be used for calender-coating paper or for injection molding, 12,500 for compression-molding compounds, 15,500 for stiff sheet stock and 21,000 for highly plasticized sheet and extruded wire coatings.

General characteristics

Polyvinyl acetate is an odorless, tasteless, non-toxic, slow-burning, lightweight, colorless thermoplastic which has reasonably low water-absorption characteristics. It is soluble in organic ketones, esters, chlorinated hydrocarbons, aromatic hydrocarbons and alcohols. It is insoluble in water, aliphatic hydrocarbons, fats and waxes. It is compatible with nitrocellulose and to a lesser degree with shellac, dammar, rosin and ester gum. Where required, certain of the plasticizing esters, such as ethylhexoates, phthalates, glycollates and phosphates can be used to impart flexibility. The resin is

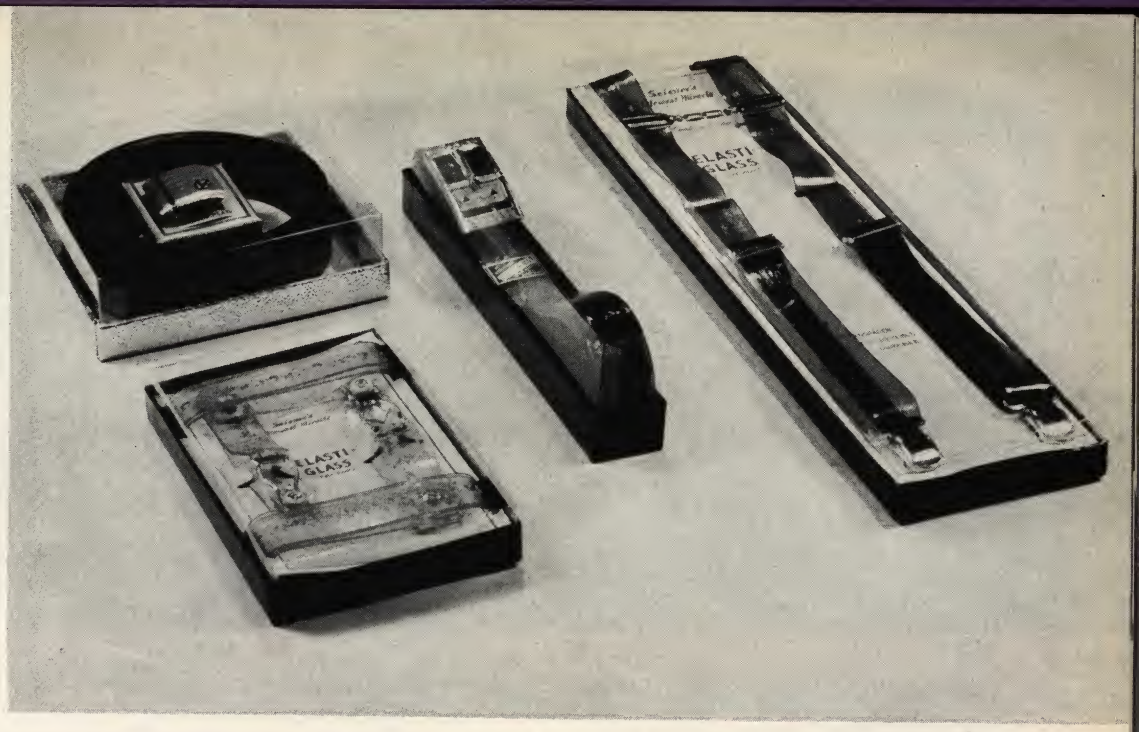
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3



2—Good looks as well as practicality mark "Exylin" vinyl-type wearing apparel. Offering protection, it is light in weight and waterproof. 3—Wilco glass cleaner solution sprayers are of Vinylite, injection molded by Modern Plastic Co. Unaffected by the cleaning solution, they are tough enough to withstand hard usage



4—Elasti-Glass, highly plasticized clear Vinylite belts, garters and suspenders, among the many new items made by S. Buchsbaum & Co., mark a new departure in men's haberdashery. Packages are fabricated by Parfait Powder Puff Co., Inc., from clear and blue unplasticized copolymer sheets

4

produced in five standard viscosities, 2.5, 7, 15, 25 and 60 poises.

The material for use can be dissolved in many common solvents, mixed with plasticizers or used as a hot melt. Its chief uses are in adhesives, metallic inks, binders for wood flour and certain molding applications. Due to its excellent aging qualities, its lack of odor, taste or color and its good adhesive properties, the resin is widely used as an adhesive for food cartons and drinking cups, and for laminating cellophane and cellulose acetate. Because it imparts high gloss and has a zero acid number, it is meeting increased acceptance in metallic lacquers and inks. Mixed with fillers, its low shrinkage suits it well for moldings of intricate design and for plastic woods.

Polyvinyl chloride is a thermoplastic resin, odorless, tasteless, non-toxic, non-burning and clear, having excellent chemical resistance and very low water absorption. It is not readily soluble at room temperature, but may be dissolved at somewhat higher temperatures in dioxane, mesityl oxide and chlorinated hydrocarbons. Typical plasticizers are tricresyl phosphate, dibutyoxy ethyl phthalate, triglycol dihexoate and dibutyl phthalate. The resin is incompatible with most other resinous materials and, due to its comparatively high softening point, it is plasticized for most uses.

Its chemical resistance, freedom from oxidation, low water absorption, good electrical properties and toughness have resulted in wide usage of polyvinyl chloride for extruded wire coverings, flexible tubings, gaskets and other applications that require a material that must not fail under corrosive conditions.

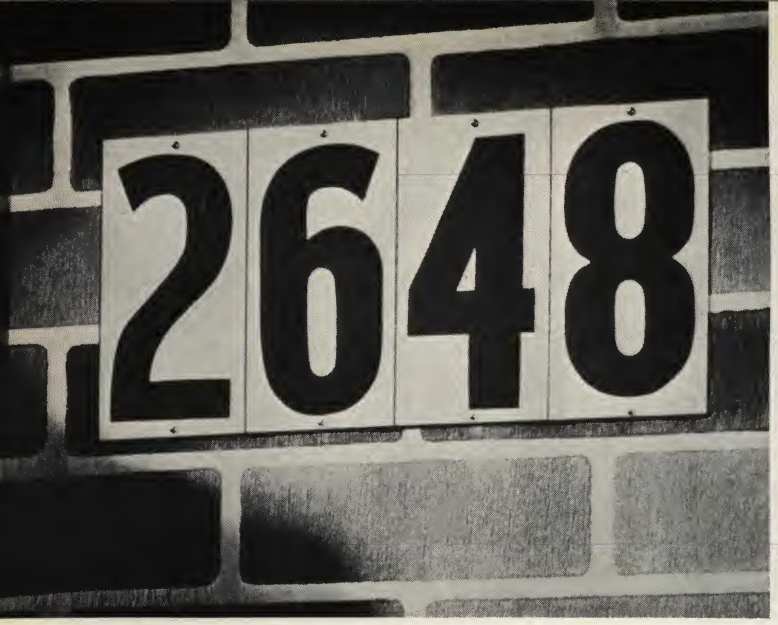
Copolymerized vinyl chloride and vinyl acetate is a thermoplastic resin of marked versatility, for it combines the best properties of polyvinyl chloride and polyvinyl acetate into a single material. It is odorless, tasteless, non-toxic, non-flammable, non-warping, non-shrinking, tough and has excellent water and chemical resistance and dielectric properties. This material is produced in a variety of molecular weights for varied applications. The best solvents for the material are ketones, chlorinated hydrocarbons, esters and polyethers, although ketones are preferable as the active solvent. Coal-tar solvents swell the resin and may be used as diluents. As this resin is internally plasticized by the combined polyvinyl acetate, it requires less plasticizer than polyvinyl chloride to impart the same degree of flexibility. Plasticizers for the copolymer are essentially the same as mentioned for polyvinyl acetate resins. The many excellent properties of copolymer resin are rapidly increasing its use and broadening its field of application.

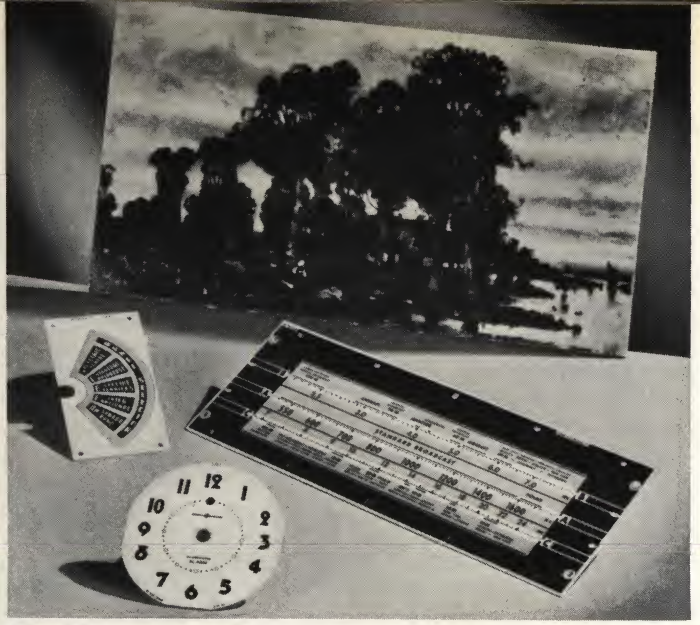
Developments during 1940

Polyvinyl acetate developments have included a broadening of older uses, rather than the inception of many new applications. Impervious materials, even glass and metals, are now bonded with this resin or with modifications of it. In some cases the resin is simplifying assembly of small electrical devices, particularly where precision assembly of stamped parts is important. The material's use in loudspeaker housings and phonograph motors are outstanding examples.

In the form of calendered shapes, polyvinyl acetate is an excellent heat-sealing tape for paper. This difficult development has resulted in a product which can be laid between sheets of paper to fasten them by a simple heat-sealing operation. Polyvinyl acetate is also being used as the "holding" material in small photoflash bulbs. The insulating qualities of the resin keep hot particles of metal from touching the glass and act to prevent the glass from shattering. Polyvinyl acetate is also being used on tapes for sealing various types of food packages in addition to the milk cartons, hot drink cups and similarly established adhesive uses in the food industry.

Polyvinyl chloride is being used more and more extensively for impregnating fabrics, both for industrial and domestic uses. Industrial applications include fabrics used for wrapping underground pipe lines to prevent





5 6

5—Individual Plastine house numbers made by Sillcocks-Miller Co. from Vinylite sheets are printed on a standard size sheet. The ink is over-laminated with vinyl resin film insuring sharp contrast and gloss. 6—Radio and clock dials cut from and printed on vinyl sheets, as well as lithographic prints on paper, are shielded from effects of moisture, finger prints and atmosphere by vinyl resin surface film

corrosion, while the other fabrics, particularly silks, are impregnated with this solution to be made into raincoats, tobacco pouches and curtain material, for both waterproofness and stainproofness.

Plasticized materials in both the extruded and sheeted forms are also gaining wider acceptance. Extruded material is used for coating wire for low-voltage and telephone work, while sheeted material is used principally for its high chemical resistance, such as in chromium-plating tanks. The toughness, lack of taste or odor and high resistance of the material to many corrosive agents all combine to make it well suited for these applications.

Copolymerized vinyl chloride and vinyl acetate has been the basis of several unique, new extensions of the plastics industry during 1940. Two of these developments promise to open new fields for plastics—as synthetic fibers, and as flexible, elastic materials in sheet form. Among the molded parts now being made of these resins are combs, toothbrush handles, hair curlers, glass-cleaner sprayers and various ornaments.

When spun from an acetone solution on equipment similar to that used for making acetate rayon, these resins produce a textile fiber of high strength and outstanding chemical resistivity. Details concerning this fiber are given in a separate article (see page 443), so it will suffice to say here that textiles from these synthetic textile yarns are now fully commercial and are entering into many new industrial uses.

Highly plasticized calendered sheeting is a truly "elastic plastic." This unusual material has many of the advantages of leather and rubber, yet it can be made transparent or in any color. It will not oxidize, yet can be made waterproof, oilproof and greaseproof, or nonflammable. It can be stretched to as much as $2^1/_2$ times its normal length and returns to its original size and shape slowly and easily. This material, first made into belts, suspenders and garters, has been widely accepted and is now being used either by itself or in conjunction with other materials for women's and children's footwear, wrist watch straps, raincoats and many water-proof articles. With special plasticizers, the material is being used for automobile ignition "harness" tapes, for extruded wire insulation, "spaghetti" tubing, ribbons and for certain chemical uses.

In sheet form, copolymer resins are now used for transparent packages, airplane window frost shields, watch crystals and windows for water-level control instruments. Uses of this nature are increasing rapidly as the material combines many properties not obtainable in other thermoplastic sheets. Its ease of fabrication, low moisture absorption and low moisture vapor transmission, together with its high strength and permanence of dimensions, fit it admirably for these and other uses.

Forms available

Polyvinyl acetate—Granular powders and solutions.

Polyvinyl chloride—Granular powder, plasticized sheets, extruded tubes and special shapes.

Copolymerized vinyl chloride and vinyl acetate—Granular powders, injection and compression molding compounds, rods, tubes and special extruded shapes, coated paper, calendered laminating film, calendered and finished stiff sheets, highly plasticized sheeting and highly plasticized film fabrics.

Methods of fabrication

Polyvinyl acetate—For adhesive purposes, this resin can be applied either from solution or as a hot melt. When used as a binder for molding material, it is molded in steel or special alloy molds, with pressures from 1000 to 2000 lbs. per sq. in. at temperatures from 225 deg. to 275 deg. F. Castings are cooled under full pressure to approximately 90 deg. F.

Polyvinyl chloride—With a plasticizer, this resin can be milled, calendered or extruded with standard equipment and can be used in processing rubber. Standard molds for molding thermoplastics may be used for forming. Pressures and temperatures used will be dependent on the amount and type of plasticizer, but in general 1000 to 2000 lbs. per sq. in. of casting cross sectional area, at a temperature between 225 deg. and 275 deg. F., are found to be satisfactory.

Copolymerized vinyl chloride and vinyl acetate—This resin can be milled, calendered or extruded on specially designed equipment. When compression molded, it is molded in steel at pressures of 1200 to 2000 lbs. per sq. in. of casting cross-sectional area, at temperatures of 250 deg. to 290 deg. F., and must be cooled under full molding pressure to about 90 deg. to 100 deg. F. It is injection-molded at 280 deg. to 300 deg. F. at pressures of 15,000 to 22,000 lbs. per sq. inch.

Sheet stock can be press-polished, laminated, embossed, drawn, swaged, blown, rolled, bent, stamped, sheared or cemented. Over-lacquers, wipe-on paints and printing inks can also be applied to this material.

Typical applications

Polyvinyl acetate

- Adhesives
- Inks
- Plastic woods
- Metallic paints
- Molding compounds (with fillers)

Polyvinyl chloride

- Cable coverings
- Coated fabrics
- Extruded tubes
- Tank linings
- Molded articles
- Power-transmission belts
- Impregnated tape

Copolymerized vinyl chloride and vinyl acetate

- Sound records
- Films
- Floor tile
- Sheets
- Electrical tapes
- Plating tanks
- Pen parts
- Plastic bindings
- Hair curlers and combs
- Drawing instruments
- Cleaning sprayers
- Radio dials
- Cable coverings
- Transparent packages
- Belts and suspenders
- Shoe uppers
- Garters
- Coated paper
- Metal, cement and wallboard coatings
- Raincoats
- Watch straps

Outstanding properties

Polyvinyl acetate

- Clear
- Zero acid number
- Adhesive
- Tasteless and odorless
- Non-toxic

Polyvinyl chloride

- Resistant to water and chemicals
- Non-Toxic
- Odorless and tasteless
- Tough

Copolymerized vinyl chloride and vinyl acetate

- Non-warping and non-shrinking
- Chemically resistant
- Tough, strong and rigid
- Non-toxic and odorless
- Available in colors

Trade names

Vinylite series A resins, Gelva	Polyvinyl acetate
Vinylseal solution	Polyvinyl acetate solution
Vinylite series Q resin	Polyvinyl chloride
Koroseal	Plasticized polyvinyl chloride
Vinylite series V resin, *Vinyon* fiber	Copolymerized vinyl chloride and vinyl acetate

7—Handbags and shoes of flexible Vinylite in various colors, both clear and opaque, combine with smart leathers and fabrics in a new fashion trend. 8—Evening footwear by Saks Fifth Avenue typifies this important style note

7



8



Vinylidene chloride resins*

THE year 1940 saw the introduction of a new group of thermoplastic resins, based on unsymmetrical-dichloroethylene, more commonly known by the name vinylidene chloride. The product has as its raw materials the almost limitless domestic supplies of crude oil and brine. Vinylidene chloride resin is barely mentioned in a recent comprehensive survey of resinous materials. For some time, however, it has been investigated in a few industrial research laboratories and is now directly or indirectly the subject of some 40 patents. While vinylidene chloride plastic has just been made available in commercial quantities, it has found a number of new and useful applications, particularly in its extruded forms.

1—Dow Chemical Co.'s vinylidene chloride extruded by Pierce Plastics, Inc., is used for fishing leaders, snells and trolling lines as these by Weber Life-like Fly Company. 2—Sturdy, washable subway seat covers are of woven Saran, vinylidene chloride extruded by Irvington Varnish & Insulator Company



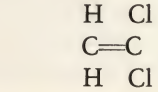
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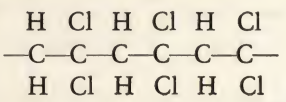
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Chemistry of formation

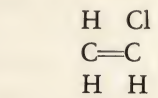
Vinylidene chloride is a clear, colorless liquid, with a characteristic odor. It boils at 31.7 deg. C. and has the structural formula:



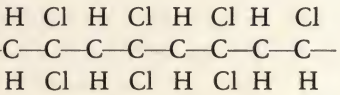
The liquid monomer may be polymerized in a long linear chain by the direct linking together of the monomer molecules, to form an insoluble white crystalline powder which may be represented as follows:



A wide range of properties may be obtained either by controlling the length of the chain or by using a copolymerizing agent or both. In the case of the latter a suitable copolymerizing agent might be a vinyl type monomer, such as, for example, vinyl chloride:



In this process the two materials become activated together and so polymerize to form the straight chain copolymer having the possible structural formula:



Through a variation in the type and quantity of copolymerizing agents an almost infinite number of resins having widely diversified properties may be obtained.

General characteristics

Resins formed through copolymerization range from a flexible, moderately soluble material having a softening point around a range of 70 deg C. to a hard, tough thermoplastic solid having a softening point of at least 180 deg C. To a greater or lesser degree, these resins exhibit crystallinity of structure. This is an unusual property which may be demonstrated readily through the use of the x-ray diffraction pattern. The higher softening point resins show the greater degree of crystallinity.

Normally, the so-called fibrous crystals are arranged in heterogeneous manner, and when this is the case, the plastic has only ordinary properties. For example, such unoriented vinylidene chloride resin may show a ten-

* This material was especially prepared for this issue by W. C. Goggin, Special Products Div., The Dow Chemical Co.

3



3—Moderately high softening point of vinylidene chloride resin is used advantageously in the application as a bonding agent in a recently developed abrasive wheel. (Courtesy The Norton Company). 4—Small strands of continuous lengths of vinylidene chloride are twisted together to produce this Permalon cord. In addition to its decorative possibilities it has high tensile strength. Extruded by Pierce Plastics, Incorporated

4



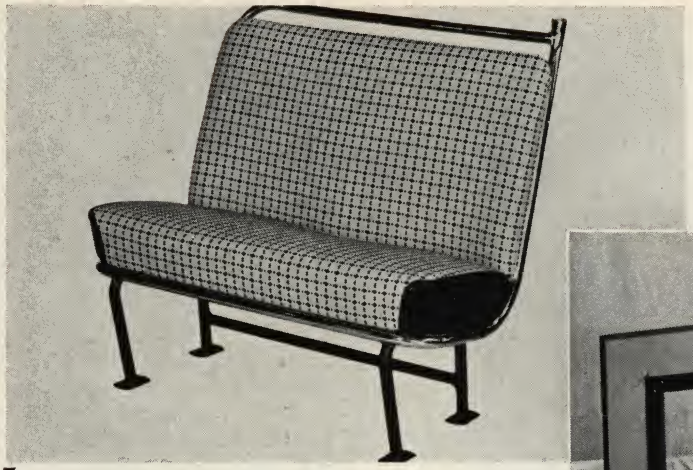
sile strength of 8000 lb. per sq. in. Under proper conditions, however, the fibrous crystals may be oriented into an orderly linear pattern which gives the resin its remarkable properties. In this manner the tensile strength may be increased to 60,000 lb. per sq. in., accompanied by a much greater flexibility. In other words, the alteration of crystalline arrangement results in a change in the modulus of elasticity; but even more striking is the great flexing fatigue life of oriented vinylidene chloride. In a series of tests this resin withstood 250,000 bends through an angle of 180 deg. over a $^1/_2$-inch mandrel without breaking.

Vinylidene chloride resins are characterized by their extreme chemical resistance. The highest softening point resins exhibit the greatest chemical resistance and the lower softening point materials, lesser resistance. As an example of its inertness the intermediate softening point material is entirely unaffected by water, inorganic salts, acids or alkalies in any concentration at ordinary temperatures. The resin is solvated only by the more active oxygen bearing organic solvents, the oxides and ethers. The resin in the oriented form exhibits even greater chemical resistance than the unoriented type.

Vinylidene chloride plastic will not burn. It is odorless, tasteless and nontoxic. The resin has a high index of refraction. Hardness and toughness are determined by the particular grade of resin used and the method of fabrication. Because of the incompatibility of this type of resin with most organic materials, only a limited group of plasticizers offers any advantages. In comparison with other plastics, relatively small amounts of plasticizer are required for facilitating fabrication. The basic resin is essentially clear, making it possible through the use of dyes and pigments to obtain almost any shade of color or range of opacity.

Developments during 1940

In spite of the fact that vinylidene chloride resins were not introduced until late in 1940 several interesting applications already have been noted. Taking advantage of the extreme strength, toughness and flexibility available in oriented vinylidene chloride strands, both commercial and sport fishermen have enthusiastically received new leaders, trolling lines and snells made from

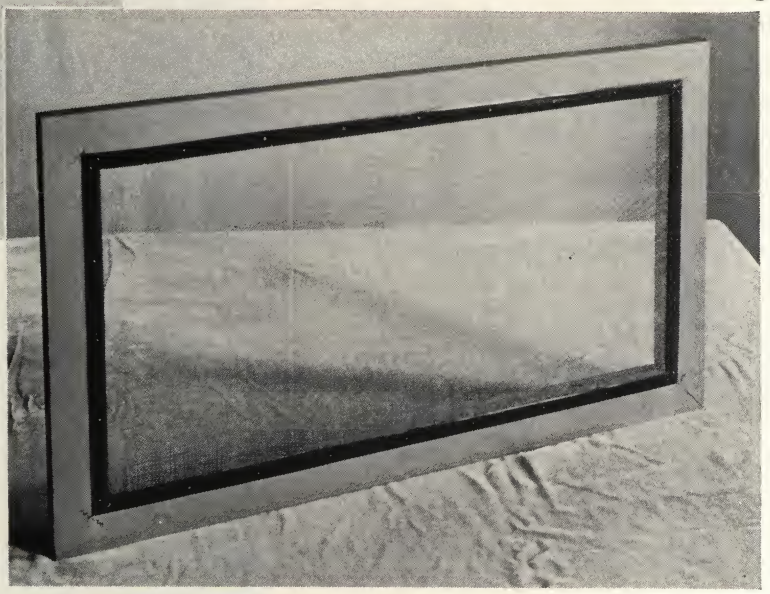


5

5—Side view of car seat with covering woven from separate colors of continuous lengths of vinylidene chloride by Heywood Wakefield Co. Variable designs are possible through changing the weaving technique

6—Woven Permalon mesh screen demonstrates how the finely extruded plastic may be applied. No painting is necessary—it will neither rust, oxidize nor otherwise corrode

6



this material. Equivalent wet or dry strength, invisibility in water, durability and availability in long continuous lengths have been decisive factors in the use of vinylidene chloride plastic to replace imported Japanese synthetic gut and best grade Spanish silkworm gut leaders. A late development in this field is the use of a special twisted construction of several filaments to form a very flexible and strong snell for salt water fishing.

An effective use of vinylidene chloride resin is in the field of transportation seating. Under the severe conditions to which subway seats are exposed, vinylidene chloride plastic has stood up remarkably well. Again crystalline orientation is employed to produce strong, flexible rattan-like strands which are woven into an attractive seat covering. Ease of cleaning, cheerful colors, durability and long wear are factors which determined this problem to be one in which vinylidene chloride plastic was indicated. Attractive woven bulkhead panels of this material are now being used in a number of the nation's new airliners.

The possibilities of woven, braided or twisted strands of vinylidene chloride plastic are still being explored. However, neither the plastic nor the market is limited to extruded sections. Polyvinylidene chloride as a pure thermoplastic, resinous bonding agent has become an essential ingredient in a new type of abrasive wheel, recently introduced to industry.

New and promising applications based on the material's extreme chemical resistance include extruded tubing, and compression and injection molded articles. These items find many applications in chemical plants, paint and lacquer manufacturing units, as well as in many other industrial processes.

Methods of fabrication

Extrusion: Much experimental fabrication work has been done on this form of processing. Special techniques and equipment have been developed by material suppliers to obtain accurate control of properties and shapes of extruded sections.

Molding: As with extrusion, injection and compression molding can be accomplished through methods developed by material suppliers.

Typical applications

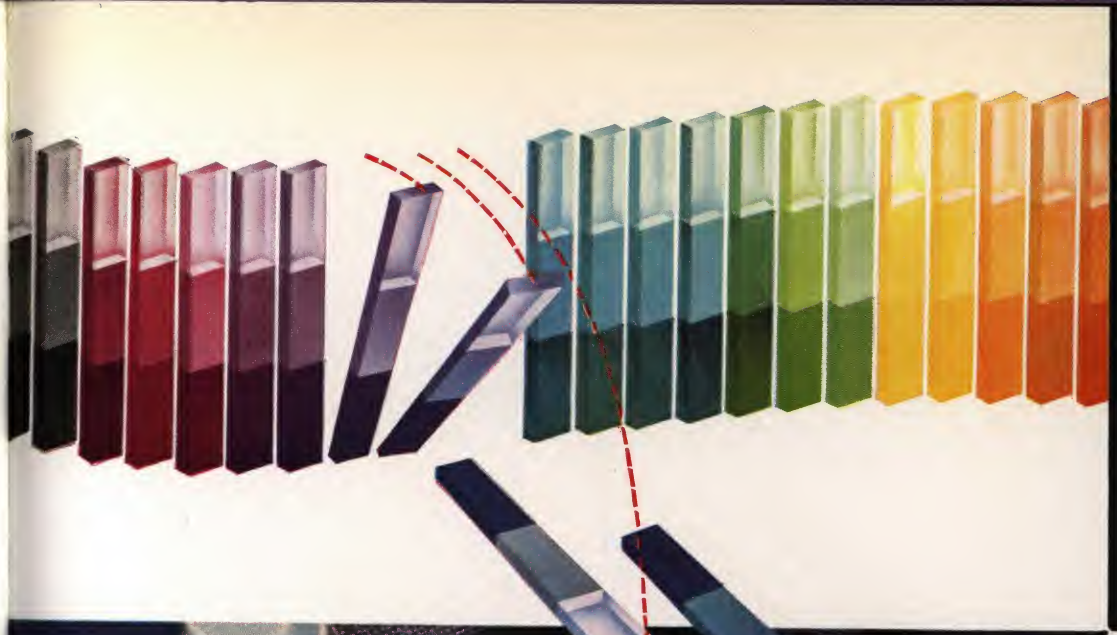
Subway car seats
Chair seats
Fish leaders
Abrasive wheels

Outstanding properties

High tensile strength
High fatigue and abrasion resistance
Toughness
Resistance to water and chemicals
Nonflammability
High dielectric strength
Ease of machining
Colorability

Trade names

Permalon, Saran, Vec



COLOR SELLS!

—especially when combined with the many additional advantages offered by

BAKELITE PLASTICS

TRADE MARKS
BAKELITE



WITH the wide variety of colorful Bakelite Plastics now available, manufacturers have extreme latitude in developing sales-winning product designs. These materials are furnished in several distinct types—Ureas, Phenolics, Acetates, Polystyrenes, and others—in translucent, transparent, and opaque effects.

Beyond rich color and sparkling luster, however, Bakelite Plastics provide many other valuable service characteristics to meet varying requirements of design, fabrication, and utility. For example, the illustrations on this and the three following pages feature the numerous benefits contributed by Bakelite Plastics to an impressive variety of consumer goods.

TRADE MARKS
BAKELITE

Study in Blue . . .

The blue grouping illustrates clearly the additional benefits obtained by color-styling with Bakelite Plastics. The deep-toned shaving accessories box of opaque Bakelite Phenolic required durability to withstand daily use. Bakelite Polystyrene provided water-resistance and delicate transparent coloring for the tray, cup, and stopper of the vacuum bottle. The transparent belt and suspenders emphasize the toughness, elasticity, and color possibilities of a "Vinylite" Plastic.

SEE NEXT PAGE





TRADE MARKS
BAKELITE

Study in Red . . .

The plus values gained by color-styling with Bakelite Plastics are typified by the following examples:

The radio cabinet of Bakelite Cast Resinoid possesses gem-like beauty and depth of color which will remain unaffected by constant handling.

The transparent hair brush, also made from Bakelite Cast Resinoid, is sanitary and promotes cleanliness, since it will withstand repeated washing.

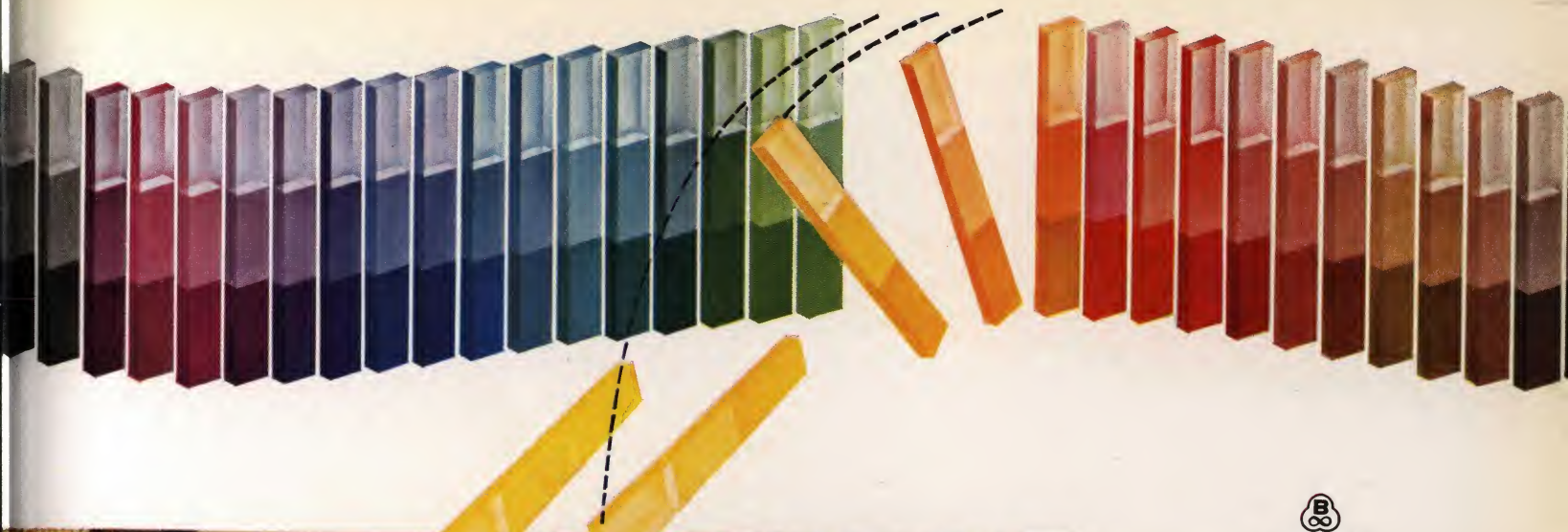
The housings of maroon Bakelite Phenolic material, for both electric shaver and massager, gain light weight, compactness, electrical insulation, and heat-resistance.

Ability to retain its brilliant color, despite the highly corrosive action of salt water, indicated the choice of a "Vinylite" Plastic for the fishing lure.

Tail-light lenses for trucks were molded from transparent Bakelite Phenolic material because of its excellent light-transmitting qualities, toughness, dimensional stability, and resistance to wear and weathering.

For sturdy playthings, such as the ocarina and cap-pistol, Bakelite Cellulose-Acetate contributes unusual toughness to withstand rough handling, in addition to exceptional luster and vivid color.

SEE NEXT PAGE





TRADE MARKS
BAKELITE

Study in Yellow . . .

Many other important characteristics of colorful Bakelite Plastics, of particular interest to manufacturers of consumer goods, are brought out in this grouping of yellow, ivory, and amber products.

The ivory radio cabinet, molded from Bakelite Urea, will retain permanently its attractive appearance, since the material is noted for its exceptional light-fastness. Another important benefit afforded by Bakelite Urea, *translucency,* is illustrated by the molded lamp shade.

The rich luster of Bakelite Cellulose-Acetate, its light weight and pleasant "feel," make this plastic an appropriate material for the bell-shaped wedding-ring case.

The safety helmet of Bakelite Laminated, although light in weight, has demonstrated its high shock-resistance by protecting workmen in hazardous industries from falling débris.

Exceptional chemical-resistance and dimensional stability of transparent Bakelite Phenolic are important reasons why this molding material is used for the amber bottle closure.

Unharmed by foods, hot liquids, or constant sterilizing, the dining tray of opaque Bakelite Phenolic possesses brilliant color and luster to win juvenile favor.

The toy automobiles feature light weight, high luster, brilliant coloring, and shock-resistance inherent in Bakelite Cellulose-Acetate.

SEE NEXT PAGE





TRADE MARKS
BAKELITE

Study in Brown . . .

The increased opportunities for practical color-styling with the greater variety of colorful Bakelite Plastics is readily apparent in this grouping.

Housings for both adding machine and reading lamp call for Bakelite Phenolic in order to provide sturdiness for the one and heat-resistance for the other.

Bakelite Cellulose-Acetate was chosen for sun-glass frames because in addition to attractive color and light weight, a high degree of shock-resistance was desired.

Unusual ability to take hard knocks and still retain its attractive appearance and efficiency was assured by selecting Bakelite shock-resistant Phenolic material for the industrial flash light.

★ ★ ★

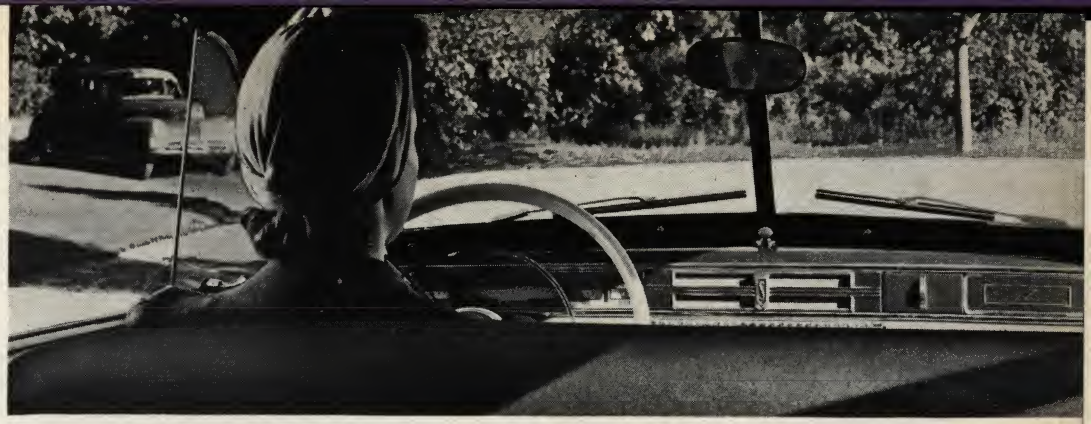
Learn how Bakelite Plastics can economically fulfill *your* color-styling and service needs by writing for illustrated booklet 24P., "New Paths to Profits." Ask also for the "Plastics Comparator" which shows tables of relative properties of various molding materials.

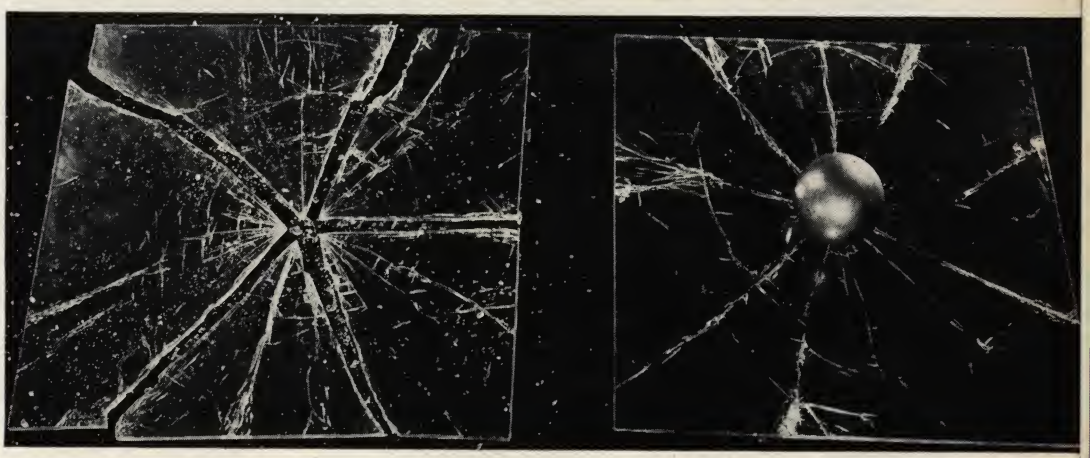
BAKELITE CORPORATION
Unit of Union Carbide and Carbon Corporation
UCC
30 EAST 42ND STREET, NEW YORK

BAKELITE

The words "Bakelite" and "Vinylite" are registered trade marks of Units of Union Carbide and Carbon Corporation

PLASTICS HEADQUARTERS





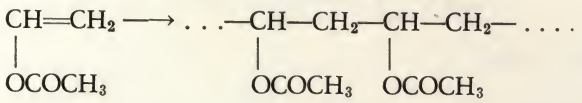
1—The clear vision and exceptional shock-resisting strength of this Studebaker windshield are made possible through the use of vinyl acetal sheet material as a laminating or bonding agent. At reduced temperatures its qualities are remarkably well maintained. 2—Test pieces show the results of dropping a steel ball weight on Butacite polyvinyl acetal laminated safety glass (right) and on unlaminated plate glass (left). Note how the shattered glass clings to the plastic layer

Vinyl acetal resins

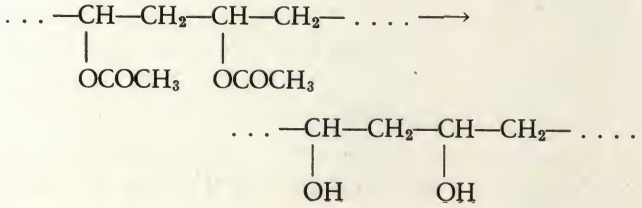
THE polyvinyl acetals are a family of resins made, on a commercial scale, from polyvinyl acetate by the successive or combined steps of hydrolysis and condensation with aldehydes.

Chemistry of formation

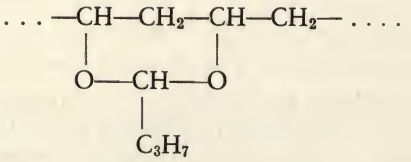
Vinyl acetate, a colorless, mobile and somewhat volatile liquid, is polymerized, usually by the application of heat in the presence of a suitable catalyst, such as benzoyl peroxide, to yield polyvinyl acetate:



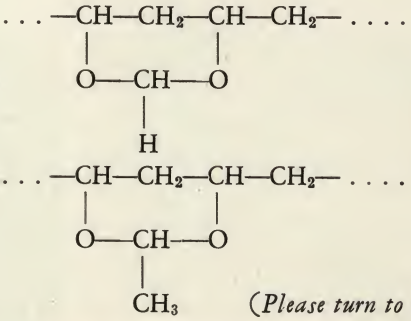
The hydrolysis of polyvinyl acetate, carried out in a suitable liquid vehicle, under the influence of acid or alkali, results in a splitting off of the acetyl groups as acetic acid, leaving hydroxyl groups, to yield polyvinyl alcohol:



Polyvinyl alcohol is now caused to react with an aldehyde, under the influence of heat and a suitable catalyst, such as sulphuric or hydrochloric acid, and one molecule of the aldehyde condenses with a pair of hydroxyls to yield a typical acetal structure. Thus a condensation of polyvinyl alcohol with butyraldehyde results in a polyvinyl butyral:



Analogously, the use of formaldehyde or acetaldehyde results in the corresponding formal or acetal



(*Please turn to next page*)

The reactions of hydrolysis and condensation may be conducted either as separate operations or together in the same reaction batch.

The resin is finally recovered as a precipitate, which is purified, stabilized and dried.

In commercial production, neither the hydrolysis nor the condensation is carried to completion because it has been found advantageous to have present in the final resin some acetyl and hydroxyl groups, as well as the acetal groups.

General characteristics

The properties of a polyvinyl acetal resin are governed by (a) the size of its molecule, which is conveniently expressed in terms of the viscosity of a solution of the resin in standard concentration in a standard solvent at standard temperature, and which is largely a function of the molecular size of the polyvinyl acetate from which it has been made, (b) the choice of the aldehyde used and (c) the percentages of polyvinyl acetate and of polyvinyl alcohol retained. A knowledge of the effects of these factors on the properties of the resin, e.g., upon its resistance to water, its softening temperature, its compatibility with plasticizers and its solubility in volatile solvents, makes possible the manufacture of a resin of the desired properties through control of the degree of polymerization effected in the first reaction, the extent of hydrolysis effected in the second and the degree of completeness of condensation with aldehyde effected in the third reaction.

From among the large variety of possible resins of this family, a few of rather well-defined types have become known as having combinations of properties most suitable for certain specific uses.

In the manufacture of safety glass interlayer, the resin ordinarily used is a polyvinyl butyral containing a very small percentage of polyvinyl acetate and a moderate percentage of polyvinyl alcohol. The optimum type for this purpose has become quite definitely established, and resins which deviate more than a very little from the established standards of viscosity and composition are found unacceptable.

Of the various resins which can be made by condensation with acetaldehyde, several have been found particularly acceptable for molding by compression or by injection. The molding temperatures are in the ranges 100 to 130 deg. C and 170 to 190 deg. C, respectively. Such properties as softening temperature, impact strength and water absorption are influenced by the viscosity and constitution of the resin. These resins, like the butyrals, contain residual acetyl and hydroxyl groups.

Of the resins made by condensation with formaldehyde, one of high formal content has received favorable notice as the basis for an insulating enamel for wire. This resin has a high softening temperature, requires a relatively high temperature for compression molding, and is not suitable for injection molding, but others of this group can be molded by injection.[2]

For uses now in course of development there will be required resins of types different from those now in commercial production.

Developments during 1940

Of chief interest is the extension of the use of vinyl butyral resins in safety glass and its experimental use in the Vidal process for making plastic-plywood airplanes.

Forms available

Interlayer sheeting of polyvinyl butyral for safety glass, made in continuous lengths and sold in rolls.

Molding compounds.

Methods of fabrication

Manufacture of safety glass: Interlayer sheeting is bonded between sheets of glass by application of heat and pressure, without or with the use of an intermediate adhesive.

Molding by compression and by injection.

Typical applications

Safety glass.

Bonding resin.

Outstanding properties

The superiority of resins of this class for safety glass interlayer results from their toughness, adhesiveness, insensitivity to moisture, stability toward light and heat and, in particular, from the fact that, when compounded with certain plasticizers in proper proportion, they are tough and yielding at ordinary temperatures and retain this toughness, as well as their adhesiveness, to an unprecedented degree at both winter and summer temperatures and in humid or dry climates.

Trade names

Alvar (acetal), *Butacite* (butyral), *Butvar* (butyral), *Formvar* (formal), *Vinylite X* (butyral).

3



4



3—Continuous length vinyl acetal sheet being inspected while under production at the Monsanto Chemical Co. plant. 4—Laboratory demonstration by Du Pont of vinyl acetal safety glass interlayer showing how it yields under impact

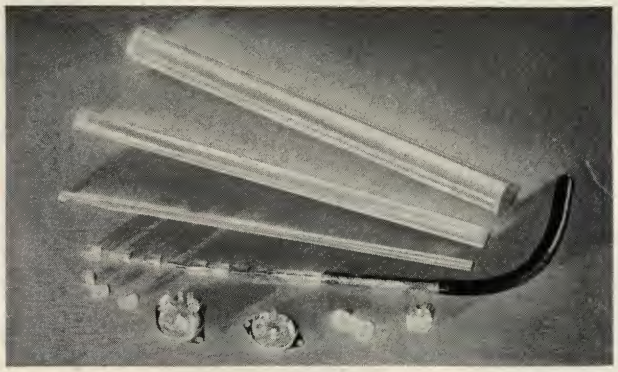


FOR COLOR IN PLASTICS—IT'S Calco

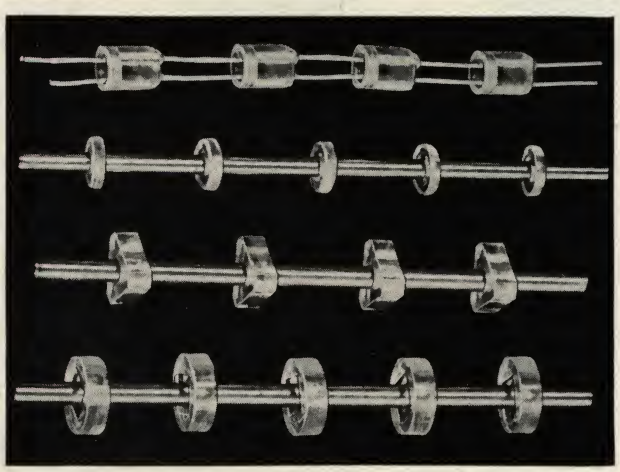
It is color that puts eye-appeal—and sales appeal in plastics. There are no finer colors for plastics of all types than Calco colors. The range of Calco shades is complete. We have full facilities for experimental molding and proving of matches, and the helpful assistance of our Technical Service men is based on their practical experience with plastic problems of all types.

CALCO CHEMICAL DIVISION
AMERICAN CYANAMID COMPANY
Bound Brook, New Jersey
Boston · Philadelphia · Providence · New York · Charlotte · Chicago

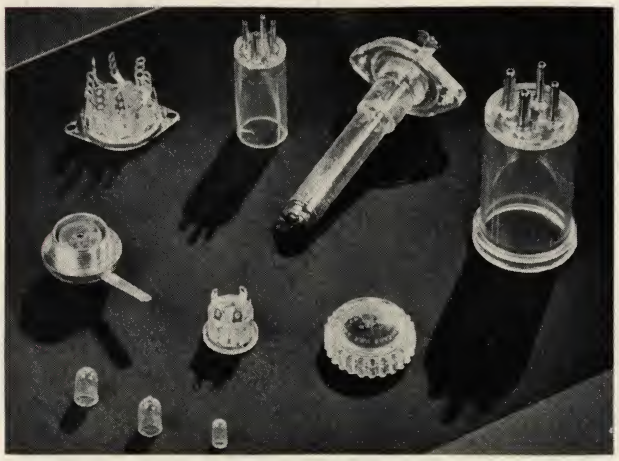
Styrene resins



1



2



3

1—Maximum electrical efficiency in stand-off and lead-in insulators, coil forms, rods and tubes is secured through Monsanto Polystyrene. 2—Interlocking beads of Amphenol, strung on television coaxial cables, allow full insulation with flexibility. 3—Low-loss coil forms for high frequency receivers and low power transmitters, and sockets that eliminate drift at tube bases of Bakelite Polystyrene. All molding, American Phenolic Corporation

POLYSTYRENE, the clear, transparent resin obtained from the polymerization of monomeric styrene, is one of the most recent of the plastics to acquire an economic significance. Although it has been known to science since 1839, it was not introduced as a transparent plastic in this country until a scant three years ago, when new developments made possible the production of a pure material in quantities.

The water-white monomer from which polystyrene is derived was isolated by Bonastre in 1831. He produced it from a distillation of storax (styrax)—a purified form of the balsam obtained by wounding the bark of the *Liquidambar Orientalis*, a tree indigenous to the region southwest of Asiatic Turkey.

The thermal polymerization of monomeric styrene by the action of sunlight was initially observed in 1839 by Simon, who named the resin thus obtained "Styroloxyd," because he thought it to be a result of the oxidation process. Later, Blythe and Hoffman gave us the first clear description of the chemical, but progress with the material was slow. It was not until 1869 that the ethyl benzene process for making it was discovered by the French chemist, Berthelot, and not until 31 years later, in 1900, that commercial possibilities were apparently first envisioned. In that year Kronstein, describing polymerized styrene as "organic glass," indicated its use in the preparation of varnishes. Eleven years elapsed before the thread he had unraveled was picked up by another, Dr. F. E. Matthews of London, who was granted in 1911 two important patents disclosing several uses. In these he pointed out the excellent insulating properties of polymerized styrene and indicated its use in place of Celluloid, ebonite, vulcanite, wood and glass in the manufacture of various articles. He noted that mixed with rubber it imparted hardness and toughness, which fact led him to suggest its use in the creation of wear- and high-temperature-resistant motor car tires.

Others were quick to follow in the trails blazed by these two pioneers. In the years immediately following 1911, considerable attention was centered upon polystyrene, both in this country and abroad, but it was doomed to be short lived.

Processes then known were highly complex and expensive, necessitating a price that the market would not meet. Still another difficulty was encountered in the seeming impossibility of fabricating a pure product—one that would not "craze" (check on exposed surfaces) or "blush" (cloud).

Polystyrene as a commercial enterprise was nearly forgotten when the world went to war in 1914, although

BEAUTY
STRENGTH
ECONOMY

•

Specify

Reilly INDUR Plastics

•



● For containers and closures that are beautiful in color and finish, exceptional in strength and economical to mold, specify REILLY INDUR PLASTICS. . . . Articles molded from INDUR combine beauty that means sales appeal with strength that insures maximum service and protection, while permitting lightness of weight in design . . . INDUR molding compounds are manufactured in several grades and degrees of plasticity, and may be had in rich blacks, beautiful mottled effects and striking color combinations.

Samples and detailed information will be gladly sent on request.

Reilly
COAL TAR PRODUCTS

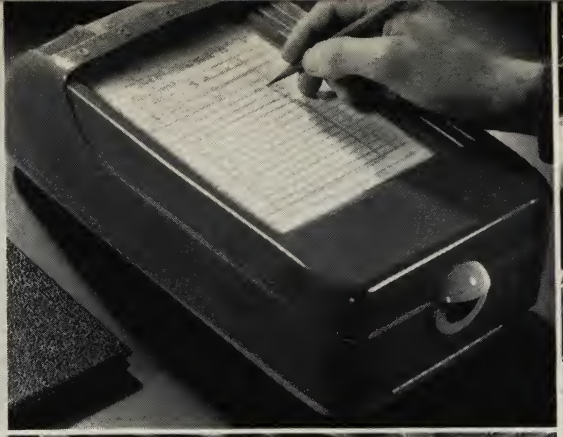
REILLY TAR & CHEMICAL CORPORATION

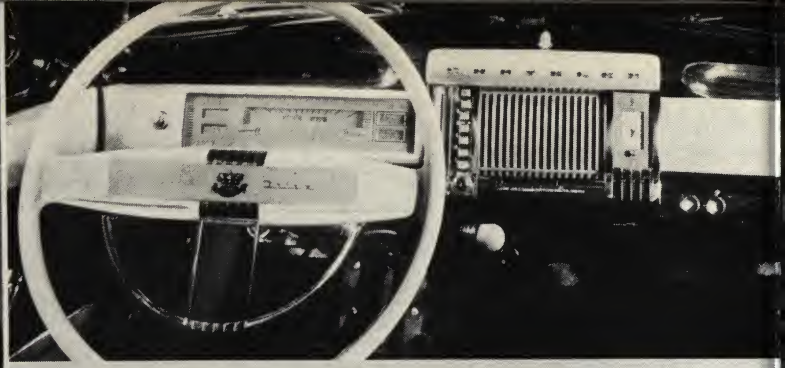
EXECUTIVE OFFICES: MERCHANTS BANK BUILDING, INDIANAPOLIS, IND.

500 FIFTH AVENUE, NEW YORK — 2513 S. DAMEN AVENUE, CHICAGO — MINNEAPOLIS, MINN.

Sales Register Housing

Molded by Sinko Tool & Mfg. Co. for United Autographic Register Co.

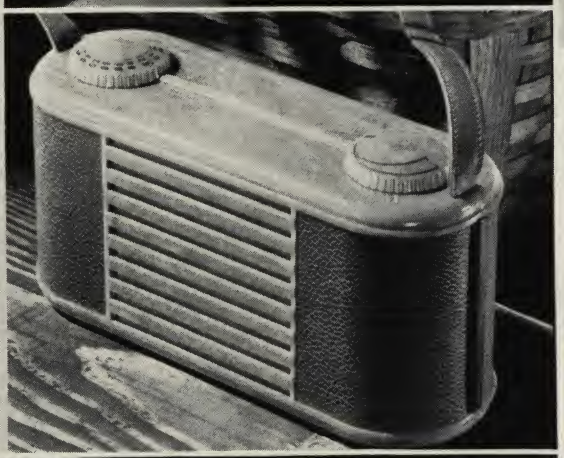




Automobile Instrument Panel *Molded by Chrysler Corp. for 1941 "New Yorker" Model*

Portable Radio Casing

Molded by Thermo-Plastics, Inc. for Philco Radio & Television Corp.



TENITE in the Fifth Plastics

JUDGES select Tenite as the outstanding material in this year's plastics developments. These 14 winners are typical of the variety of products now being molded of Tenite.

Exceptional strength, beauty and durability, combined with excellent molding properties, make Tenite one of the most versatile plastics on the market. It is available in an unlimited range of colors, including transparent, translucent, opaque, and variegated effects.

A 28-page illustrated book on the uses of Tenite will be sent on request. Technical literature on its molding and physical properties is also available.

Broom Shoulders

Molded by Elmer E. Mills Corp. for Rich & France Co.



Nameplates

Molded by Gits Molding Corp. for The Whiting Corp.



Chessmen *Molded by Ability Mold & Die Works for Gallant Knight, Inc.*



Arch Supports

Sheet Stock Molded by Insulation Mfg. Co., Inc. for Brooklyn Arch Support & Foot Appliance Laboratory





Woven Furniture *Strips extruded by Detroit Macoid Corp. for Ypsilanti Reed Furniture Co.*

WINNERS

Annual Modern Competition

TENITE REPRESENTATIVES: *New York*, 10 East 40th St. *Buffalo*, 1508 Rand Building. *Chicago*, 2264 Builders' Building. *Detroit*, 904-5 Stephenson Building. *Leominster, Mass.*, 39 Main St. . . . Pacific Coast: Wilson & George Meyer & Company—*San Francisco*, Federal Reserve Building; *Los Angeles*, 2461 Hunter St.; *Seattle*, 1020 4th Ave., South.

☆ ☆ ☆

TENNESSEE EASTMAN CORPORATION
KINGSPORT, TENN.

Subsidiary of the Eastman Kodak Co.

Shower Nozzles *Molded by Thermo-Plastics, Inc. for Mueller Brass Co.*





Bathroom Scales Housing

Molded by National Lock Co. for The Brearley Co.



Greeting Cards

Molded by Belmont Molded Plastics, Inc. for Gibson Art Co.



Oil Containers

Molded by Remler Co., Ltd. for Tri-Pak Gun Kit, Inc.



Football Helmet

Molded by Sinko Tool & Mfg. Co. for John T. Riddell, Inc.



Bugles

Molded by Elmer E. Mills Corp. for Chicago Musical Instrument Co.

both during and after the war considerable developmental work was done with the material in Germany.

In 1922 Dufraisse and Moureu discovered agents which would retard polymerization of styrene, so that it could be shipped for redistillation and further polymerizing.

It was not until 1933 that American interest in polystyrene was reawakened to any considerable extent and domestic manufacturers once more adopted it for investigation. At last they were to solve its problems and give it a place among the growing list of plastic materials useful to man. In 1937, for the first time, after nearly a hundred years of research, American companies were able to produce a pure material of high quality in commercial quantity at a price comparing favorably with that of other plastic materials.

Chemistry of its formation

Styrene is prepared by splitting hydrogen from ethyl benzene. The latter can be obtained from natural sources or synthesized from ethyl chloride and benzene. The styrene, $C_6H_5CH=CH_2$, is polymerized by the action of heat under conditions which will provide the desired polymer. In general the factors which influence the degree of polymerization or chain length are the temperature of polymerization and the purity of the styrene.

The rate of reaction, that is, the rate of conversion of styrene to polystyrene, decreases as the concentration of the styrene in the reaction mixture decreases. Catalysts such as benzoyl peroxide, oxygen and stannic chloride may be used to increase the rate of reaction but the resulting polymers will be of lower chain length than those produced without catalysts at any given temperature.

The formation of the polymer seems to be a chain reaction and not a step-wise condensation. For all practical purposes the chain length of the polymer formed at the beginning of the reaction does not differ materially from that formed at any later stage. It should be remembered that the chain length is not the same for every molecule but represents an average length.

General characteristics

As polystyrene is a thermoplastic resin, it is most easily and economically molded by the injection process. In general, higher temperatures are required for molding than those required for other thermoplastics, but the time cycles can, in many instances, be substantially reduced with polystyrene.

The high gloss and luster of polystyrene molded pieces and the ability of the material to reproduce accurately the finest details in the mold have improved the appearance of many articles. As the specific gravity of polystyrene is only 1.07, more pieces can be molded from each pound of stock. The runners and sprues can be cut and remolded, making the material economical to use.

In its natural state polystyrene is colorless and possesses an index of refraction of about 1.60. Therefore, it can be made in all colors and pastel shades, and in all degrees of transparency. These colors are noted for their non-bleeding characteristics, regardless of temperature or humidity conditions. Mottled or variegated effects are also easily obtained.

Although polystyrene is a thermoplastic resin, it has excellent stability characteristics. Its cold flow, under high loads, is practically negligible at room temperatures. At slightly elevated temperatures, it also retains its molded shape, as it has a high distortion point—78 deg C. by the A.S.T.M. heat-distortion test. These properties, with low after-shrinkage, make this material highly suitable where close tolerances must be held at slightly elevated temperatures or for long periods of time at normal temperatures.

Applications

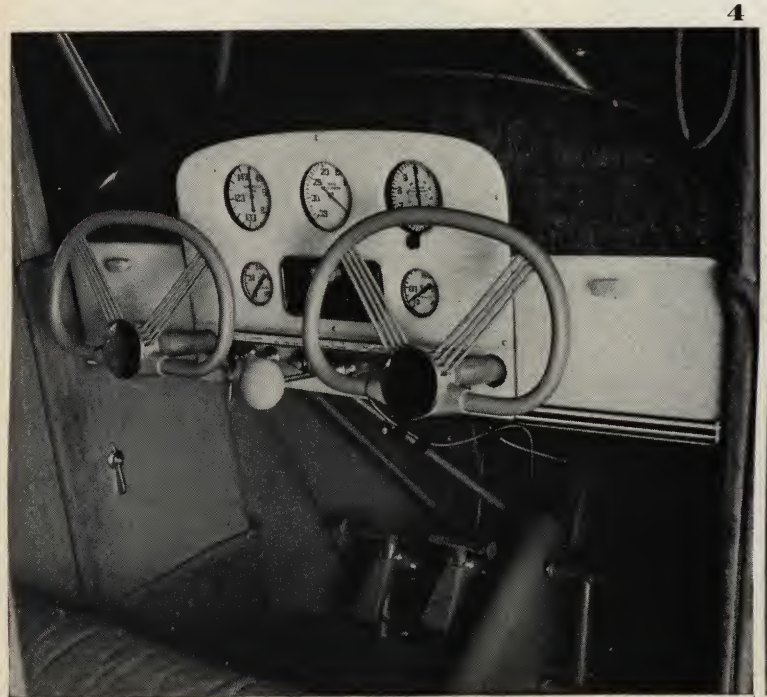
In the chemical industry a great improvement has been made in the packaging of mineral acids by the use of molded polystyrene closures, because the material is resistant to high acid concentrations. Each type of acid can be quickly identified by the color of the closure. These closures eliminate contamination and make the task of opening the bottle much easier than formerly.

Another improvement in chemical laboratory equipment is the acid bottle adapter, which is designed to fit

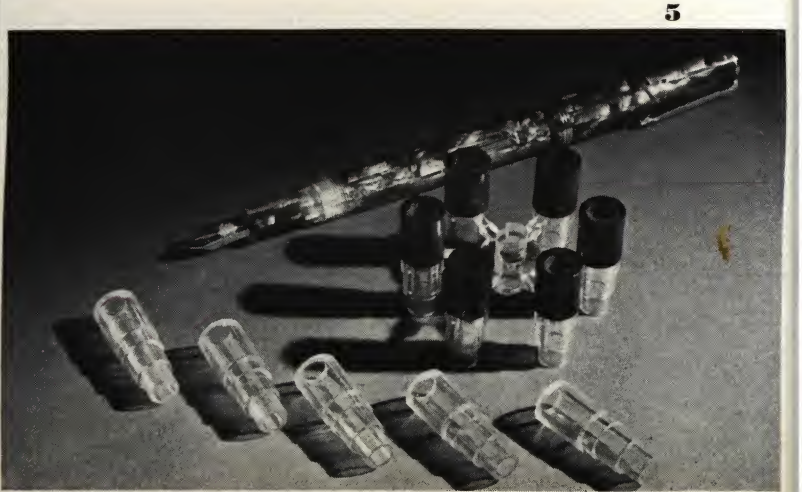
(Please turn to page 81)

4—Five large injection molded Monsanto Polystyrene parts dress up the Aeronca airplane instrument panel. Molded by Metal Specialty Co. and Thermo-Plastics Div., Standard Products Co. 5—New Esterbrook fountain pen has a small Bakelite Polystyrene section which reveals the amount of ink in the barrel. Precision molded for tight fit by Erie Resistor Corporation

4



5



TRIETHYL CITRATE

A solvent plasticizer for phenolic resins, cellulose esters and ethers, and most other plastic materials. As it is capable of holding considerable amounts of water in solution it is recommended for investigation in connection with problems arising from blushing or the development of the orange-peel effect. Imparts resistance to oils.

TRIBUTYL CITRATE

A plasticizer of low volatility and high water resistance. Its compatibility with resinous and plastic materials is but slightly less than that of the corresponding ethyl ester. Has been found of value in inhibiting discoloration by light of products in which it has been incorporated.

ACETYL TRIETHYL CITRATE

Compatible with a wide range of plastic materials. Considerably less volatile and more water resistant than most ethyl esters. Of particular interest as a plasticizer for cellulose acetate.

ACETYL TRIBUTYL CITRATE

An ester of very low volatility, very resistant to hydrolysis or solution by water. These properties together with its compatibility with most plastic materials should lead to a wide range of usefulness. Has already given very promising results as a plasticizer for ethyl cellulose.

FUMARIC ACID

An unsaturated dibasic acid now available within the price range necessary for a raw material for synthetic resins. A non-hygroscopic, free-flowing product of particular interest because of its low volatility and comparatively non-corrosive nature even at elevated temperatures.

The various esters of fumaric acid can be polymerized to form products varying from viscous, non-volatile liquids to transparent solids depending upon the particular alcohol combined with the acid.

Manufacturing Chemists

PFIZER QUALITY

Est. 1849

CHAS. PFIZER & CO., INC.

81 Maiden Lane, New York

444 West Grand Ave., Chicago

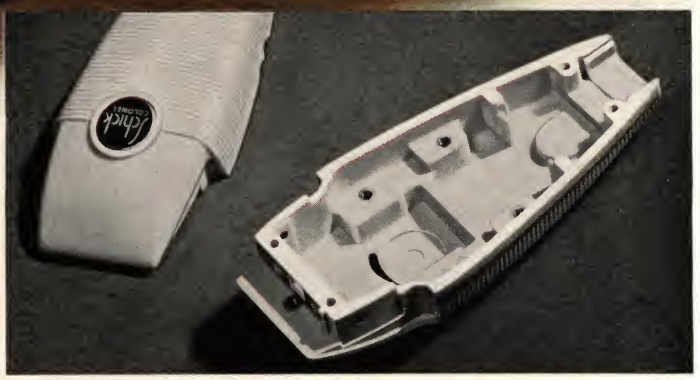
new BEAUTY *and* EFFICIENCY



SCHICK SHAVER DEMONSTRATES HOW BEETLE MEETS ALL BASIC REQUIREMENTS OF A SALES WINNING DESIGN

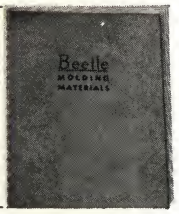
Designed by Raymond Loewy and molded of BEETLE* in cream and maroon colors, this new 1941 Schick Shaver won top award in the Annual Modern Plastics Competition. It has a simple but powerful appeal and is eminently practical—strong, compact, sanitary, economical to produce. The fluted surface, part of the functional design, is obtained in Beetle in the single molding operation—no extra production steps are required. Beetle's insulating value for both electricity and temperature also contribute to making it the ideal material for this type of product. Add to these advantages the brilliant, permanent color that is a part of the material itself and you will immediately see why Beetle is reducing the costs *and* increasing the sales of many products.

For housings of many products Beetle offers unmatched advantages. It is all color—and available in all colors. Perhaps you have a housing or product design problem that Beetle can solve in short order with quick economy. Call on our staff—a member will be glad to give you the benefit of his special knowledge of molding and materials.



Mr. Loewy's design for the Schick Shaver housing of BEETLE is an excellent example of good technique in combining beauty and functional efficiency.

This New Technical Booklet contains practical information on the properties and applications of BEETLE and new facts pertinent to modern molding methods. You will find it profitable as a reference guide in your selection of plastic parts—a copy is yours for the asking.

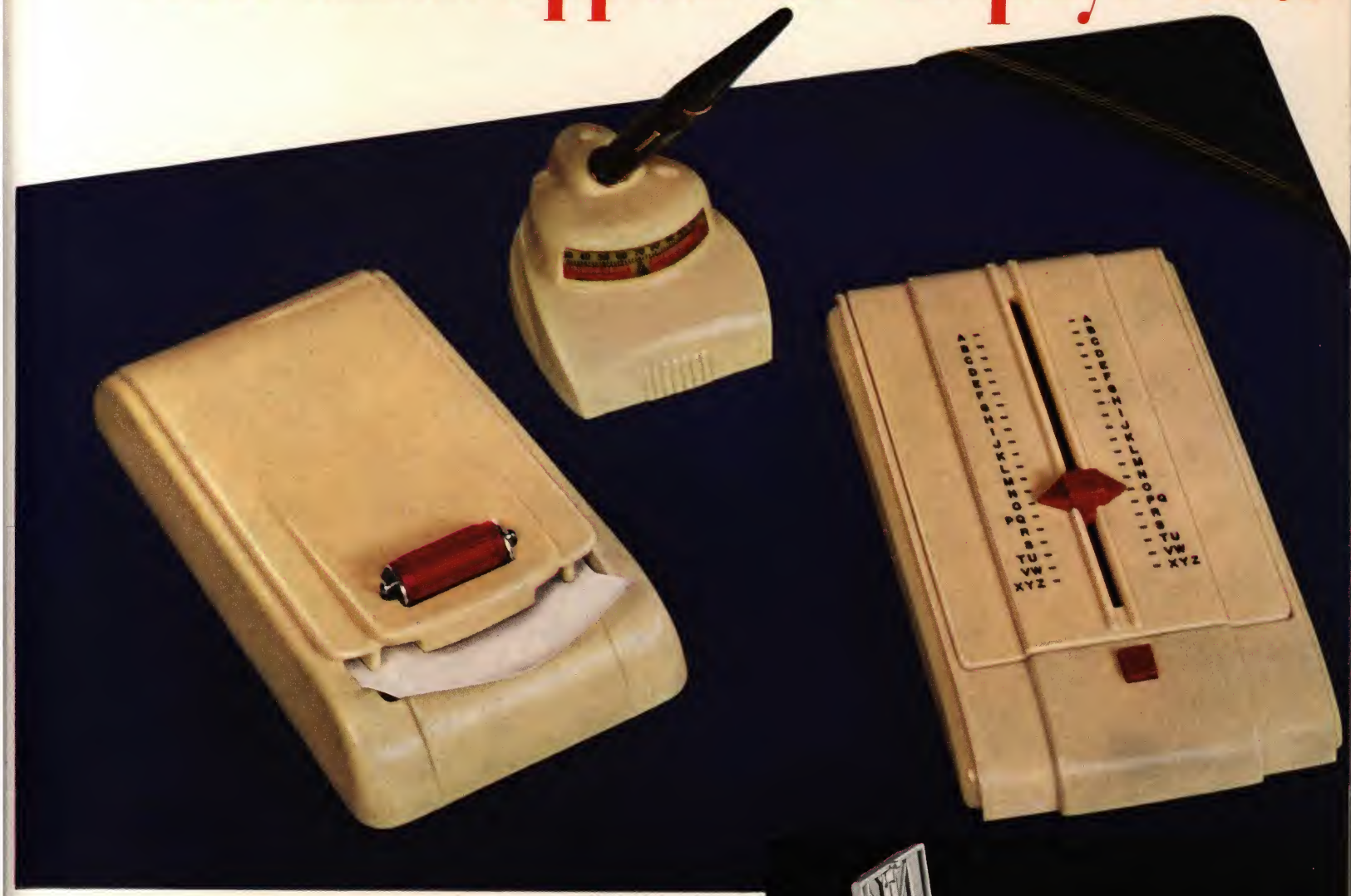


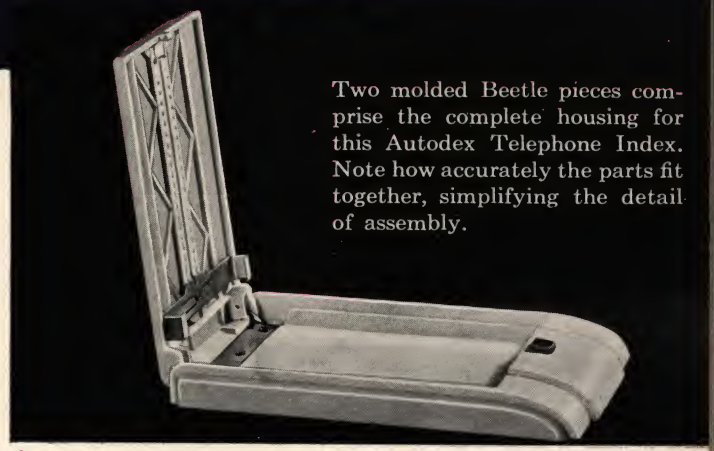
AMERICAN CYANAMID COMPANY
Beetle Products Division
30 ROCKEFELLER PLAZA, NEW YORK, N. Y.

*Trademark of American Cyanamid Company applied to urea products manufactured by it.

Beetle THE PLASTIC THAT'S ALL COLOR—IN ALL COLORS

New sales appeal for Zephyr Sets





Two molded Beetle pieces comprise the complete housing for this Autodex Telephone Index. Note how accurately the parts fit together, simplifying the detail of assembly.

BEETLE GIVES ADVANTAGES OF COLOR, IMPROVED PRODUCT, AND LOWERED COSTS

The new Zephyr Desk Sets, molded of Beetle*, demonstrate how a product can be:

1. STYLED FOR SALES through modern designs, utilizing the color and beauty inherent in molded Beetle. Look at the clean, lustrous surface, and the brilliant, attractive ivory color.

2. INCREASED IN EFFICIENCY by giving better service to the user. Beetle is light in weight, and the smart, colorful appearance will last the life of the product.

3. PRODUCED AT LOWER COST because molded parts, made to close tolerances, are ideal for line-production methods. Fewer rejects, no wasted material, no extra steps.

That's not all: Results are in sales. Ask Zephyr American Corp., makers of Autodex, Thermodex, and Rollodex—the items shown! Or buy a set and give it a trial yourself. Visualize *your* product in colorful Beetle. We will gladly help you. Write us today.

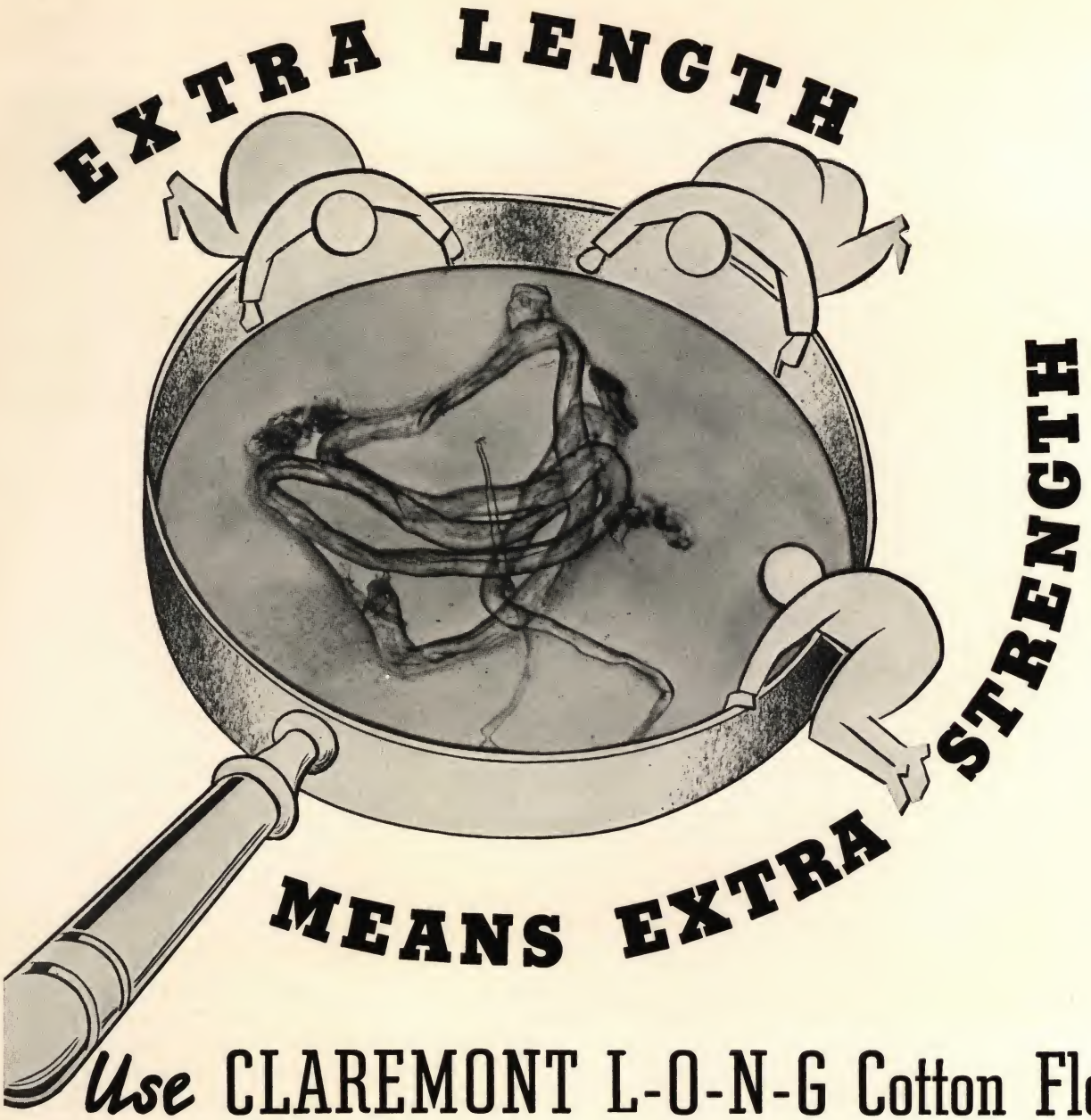


PROBLEMS IN PLASTIC DESIGN are attacked vigorously and with results at the Stamford Research Laboratories of American Cyanamid Company. The equipment is of the most modern type for testing, analyzing and developing materials for specific purposes. The work done with these extensive facilities is in line with the Cyanamid policy of assisting customers in the use of many types of plastic products.

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Beetle THE PLASTIC THAT'S ALL COLOR—IN ALL COLORS



Use CLAREMONT L-O-N-G Cotton Flocks

Cotton, long known as the strongest filler, is doubly effective when its fibers are long. Extra length in the filler gives extra tensile, impact, flexural strength to your plastics—for the filler is the primary determining factor in the strength of the material.

Claremont cotton flocks are not only longer and tougher. They are *cleaner*, free of the impurities that can ruin the strength and texture of the finest resins.

In color, which is so important in modern merchandising: Claremont flocks are uniform and properly graded to enhance the color of your plastics.

Well over 22,000,000 pounds of clean, uniform, long-fibered cotton flocks have been supplied to practically every leading molder by Claremont. Our special machinery and quick service are instantly available to meet your filler needs. Quick deliveries to any point in the United States or Canada.

CLAREMONT WASTE MFG. CO.

CLAREMONT NEW HAMPSHIRE

THE COUNTRY'S LEADING MAKER OF COTTON FLOCKS

(*Continued from page 76*) the new screw type bottle and is joined to an automatic burette. This adapter not only aids in the preparation of chemical solutions, but also eliminates the possibility of acid burns from spilling and careless handling.

Polystyrene has equally good resistance to alkalies and hydrofluoric acid. As these two chemicals attack glass, polystyrene containers are used for accurate analytical work which requires the use of these chemicals. It is likely that in a few years we may witness a complete change in the packaging of hydrofluoric acid by employing a transparent molded container of polystyrene. This material could also be used in textile equipment, battery housings, electroplating equipment, or other parts where chemical resistance, lightweight, or visibility is desired.

As polystyrene is not affected by alcohol or water and does not give off offensive odors or taste, it is used widely for molded liquor dispensers and other bar accessories. Here, color and molded design make for easy selection of your favorite beverage. Perhaps, in the future, advantage will be taken of these properties to create molded closures for bottled liquors in such a form as to improve the appearance of the package and identify the individual brands.

In the packaging field, especially in the packaging of cosmetics, polystyrene meets the requirements of beauty and utility. With its high index of refraction, with its wide variety of colors, and with its high gloss finish, polystyrene can be used in the molding of packages which present the luxurious effect we associate with cosmetics. Here, the package designer can create containers with color effects that have been unobtainable in the past except at great cost.

Polystyrene is employed for both decorative and utilitarian purposes in the refrigeration industry. Inasmuch as it does not become brittle or lose strength at temperatures as low as −30 deg C., remains unaffected by moisture, does not give off or absorb odors or tastes, it has great possibilities for panels, knobs, dials, dishes, breaker strips, and even the interior finish or trim. Because of the numerous color and lighting effects possible, the designer of the interior of the future refrigerator will certainly take advantage of these properties. A step has already been taken in this direction by one manufacturer with a polystyrene control panel, compartment front, and decorative name strips. The letters and numerals are molded directly into a crystal clear piece. They are then filled with white paint and the back is painted with a delicate shade of blue. By this process the letters and numerals are easy to read and the molded panel produces an entirely new color effect for the refrigerator interior.

One of the unusual uses of polystyrene has been to beautify the instrument panel of an airplane. An instrument panel has been made which consists of five parts—the formed aluminum-sub-panel on which the instruments are mounted, a center polystyrene plastic panel which serves as a finished cover frame for the instruments, a polystyrene plastic control panel which



6—Allied Plastics Corp. molds five separate Monsanto Polystyrene parts for the Diathermizer, therapeutic vaporizing aid. The unit resists both the medicament and the hot water which are essential to its operation

is located directly below the center panel on which are mounted the various controls and switches. On each side of the above panels are located smaller polystyrene plastic panels. The right hand panel serves as a door for the glove compartment and the left hand panel is used for symmetry of design. Provisions are also made for a radio receiver in the left hand panel and for a radio transmitter in the right hand panel in place of the glove compartment. By this method the radio receiver and transmitter are made readily available to both occupants of the airplane and the installation of the radio equipment is made more attractive.

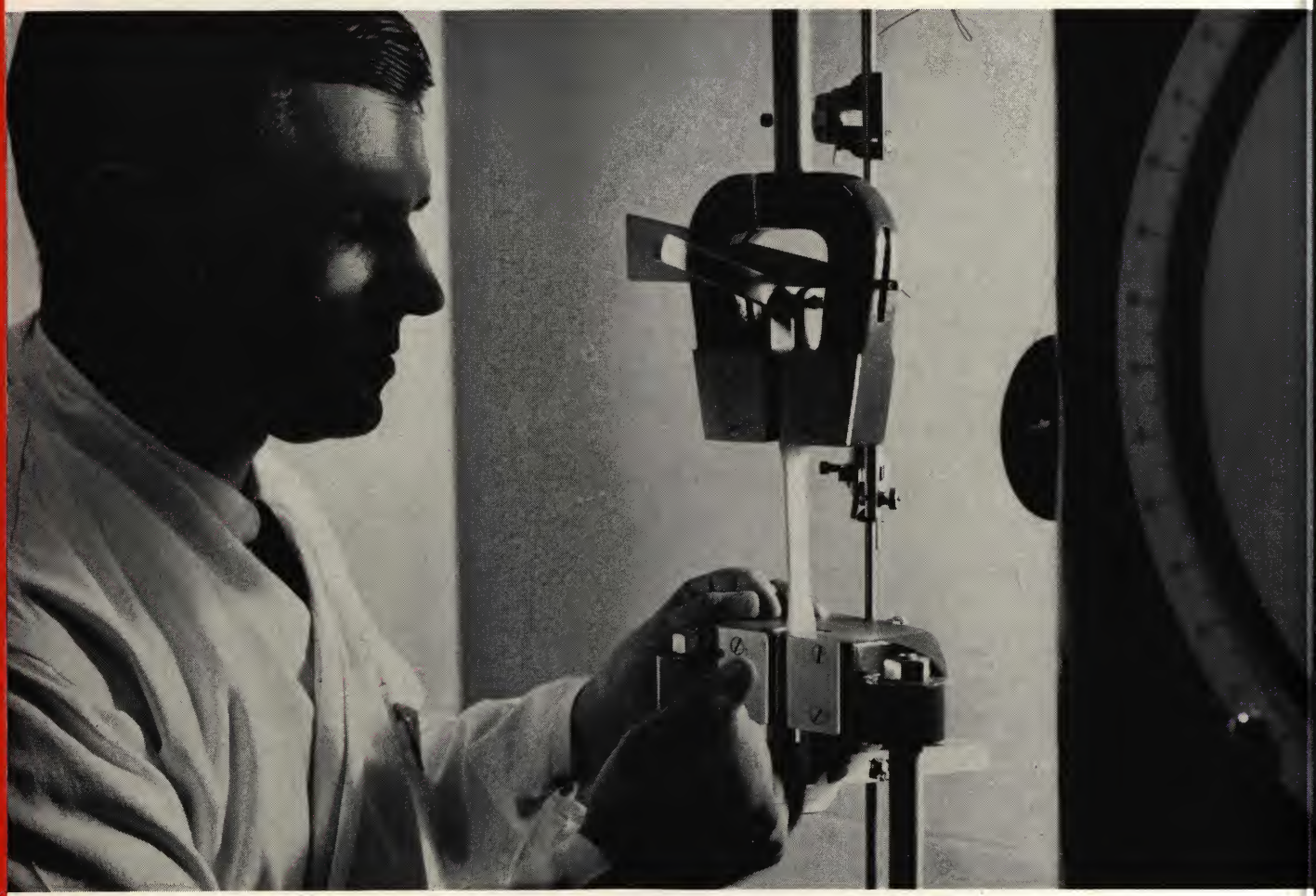
One of the unique properties of polystyrene is that it is capable of transmitting and carrying light through curved sections. This characteristic is employed in the illumination of aircraft instruments. By using polystyrene, a difficult problem in design was solved, as the material not only had to be capable of carrying light but had to withstand tropical temperatures without distortion. This was accomplished by the use of a split ring to carry the light and transmit it through an annular ring, called the *window*. Such a design provides adequate illumination of the instrument without blinding the pilot during night flying.

With this ability to transmit light around corners, the material is highly suitable for use in illuminated signs, automotive instrument panels, radio and television receiver panels, and, in fact, in any part desiring a practical but highly decorative design. Letters and numerals can be molded directly into the piece. Furthermore, the panel can be lighted from the back edge, providing a very novel effect as the numerals and letters seem to stand out with exceptional clarity.

Radio and television are claiming their share of polystyrene because it has the electrical properties which are not approached by any other molded plastic. With a power factor of 0.0002 and a dielectric constant of 2.60, polystyrene is being used to great advantage in coil forms, lead bushings, tube bases, and other parts where the ultimate in low-loss efficiency is necessary. Since the material is unaffected by moisture, the electrical

DU PONT RESEARCH..

TO DEVELOP THE NEW...IMPROVE THE OLD!



● When you select a Du Pont plastic for your product you get the benefits of all the technical skill and facilities for which Du Pont is so well known. We call this service "Du Pont Research." Actually, it is much more than these dignified words imply.

There is, of course, the type of Du Pont Research that created or improved the famous products of the Du Pont family . . . "Lucite" methyl methacrylate resin, nylon, neoprene, Duco quick-drying enamel and the others. This is the "behind-the-scenes" research that is constantly searching for the new . . . and for new refinements of the old.

But there is another, more personal, side to Du Pont research. The same technical skill and equipment are also prepared to attack any problems involved in the development of your own products made with these plastics. From this cooperation, many of the current uses of Du Pont plastics, as well as many new products, have emerged.

Again, Du Pont Research goes still further. Even when your product is ready to tempt the buying public—our research laboratories will, if necessary, test this finished product, to determine its potential performance.

Every year Du Pont spends substantial amounts for fundamental and applied research and large additional sums to maintain this "partnership" between our research scientists and the manufacturer. Take advantage of this background and experience . . . to get the best of quality and performance from your products.

DU PONT RESULTS...

WITH DU PONT PLASTICS INCREASE SALES!



● A manufacturer wrote a molder that he wished to improve the readability and beauty of his gasoline pumps. Result: an entirely new method of illuminating gas pump dial faces that depends on the "edge-lighting" property of "Lucite" for its success!

A designer came to Du Pont with a plan to direct and diffuse the wayward illumination of fluorescent tubing. Result: Louverglas, made of "Plastacele"—and a new future for interior illumination!

In 1937 Du Pont "Lucite" was practically unknown in the automotive industry. Suddenly manufacturers discovered the possibilities of this remarkable material for car use. Result: the amount of "Lucite" used by the industry today is more than *13* times the volume of 1938—a 1200% increase!

This year *Modern Plastics* sponsored a competition. Result: Du Pont "Lucite" methyl methacrylate resin, "Plastacele" cellulose acetate plastic and nylon, between them, walked away with *seven* first awards! And each award was in a *different* group!

All this means one thing . . . that out of the throng of new materials and new products that arise every year only those survive that *satisfy a special need* . . . and do it better than anything else on the market!

Du Pont plastics and the products made from them have more than survived. Month by month, year by year they prove their quality over and over again in the most exacting test of all—public approval! And month by month, year by year, you can reap more and more profits from this approval!

DU PONT REPUTATION..

CAN HELP YOU SELL YOUR PRODUCTS!



● There are, roughly, 130 million people in the United States. Theoretically, each one, at some time or other, is a potential consumer of your products. Let's see how many of these potential consumers have had a chance to see or hear the name, **DU PONT.**

- ▶ **Every week the Du Pont radio program, "Cavalcade of America," is on the air some *ten million* people listen to it.**
- ▶ **In the two years of the New York World's Fair approximately *nine million* people have visited the Du Pont Exhibit.**
- ▶ **In 1940 the Du Pont Exhibit on Atlantic City's Boardwalk entertained over *900,000* visitors.**
- ▶ **Mentions of Du Pont plastics appeared in the newspapers and magazines of *168 million* readers last year.**
- ▶ **The Du Pont oval — symbol of "Better Things for Better Living....Through Chemistry" — appears *800 million* times per year, on the average, in paid advertising media.**

This wide program of consumer education is constantly keeping Du Pont plastics in the "familiar names" class. Many manufacturers take advantage of this fame to strengthen their advertising and selling jobs. Their sales figures show it. So can yours.

Meet the Du Pont family of plastics on the next page . . . ready to help you improve your old products . . . ready to help you develop your new ones . . . ready to help you share in the profits of the vast new market which the plastics industry is opening up. E. I. du Pont de Nemours & Co. (Inc.), Plastics Dept., Arlington, N.J.

DU PONT

READY....

TO SERVE YOU

"LUCITE"
REG. U.S. PAT. OFF.

methyl methacrylate resin

(*rods, sheets, tubes, molding powder*)

Crystal clear, translucent, or opaque "Lucite" will glow with any color in the rainbow, and, moreover, has the unusual property of carrying light around its own curves. Famous for its clarity, beauty and weather resistance. Typical uses: display fixtures, medical and dental appliances, costume jewelry, auto and radiator ornaments, instrument panels, reflectors, lenses, vanity cases, airplane enclosures . . .

"PLASTACELE"
REG. U.S. PAT. OFF.

cellulose acetate plastic

(*rods, sheets, tubes, molding powder*)

This plastic offers an unlimited range of beautiful transparent, translucent, mottled, opaque and pearl effects. Its most important characteristics are non-inflammability, light weight and high lustre. Widely used for airplane windshields, advertising novelties, decorative jewelry, musical instruments, watch crystals . . .

"PYRALIN"
REG. U.S. PAT. OFF.

cellulose nitrate plastic

(*rods, sheets, tubes*)

"Pyralin" comes in practically every color and shade, and in beautiful transparent, translucent, mottled, opaque and pearl effects. Extremely economical, easy to work and shape, and very strong. Ideally suited for toiletware, fountain pens and pencils, advertising novelties, tooth brush handles, optical frames, shoe heel coverings, buttons, bathroom fixtures . . .

NYLON

for better brush bristles!

Well known in tooth brushes, hair brushes and the like, nylon bristles are now finding a wide application in industrial brushes. These bristles resist many chemicals and absorb only 1/5 as much moisture as animal bristles. Moreover, by actual usage they have proved their superior resistance to abrasion. Nylon bristles are made from the same nylon filaments that are finding so many places in widely diverse fields.



E. I. du Pont de Nemours & Co. (Inc.), Plastics Department
626 Schuyler Avenue, Arlington, New Jersey

If you wish further information we'll be glad to send you literature describing Du Pont plastics and their characteristics in greater detail. Kindly check the material you would like to receive.

- ☐ Du Pont Plastics Bulletin . . . up-to-the-minute news of current applications.
- ☐ Plastics for Products of Today and Tomorrow . . . detailed individual descriptions of the properties of Du Pont plastics.
- ☐ Parade of Plastics . . . an informative general story on the plastics picture to date.

*Name*_____

*Title*_____

*Business*_____

*Address*_____

*City*_____ *State*_____

characteristics do not vary with climatic changes, thus insuring constant performance regardless of weather.

One of the newest developments in the radio and television field is the use of polystyrene film in wound condensers of low capacitance. This film, with a thickness of about 1 mil, is wound between the metallic foils, providing excellent insulation. This one-mil film has a dielectric strength of over 3000 volts. When the efficiencies of various circuits are improved and the use of ultra-high frequencies becomes more general, polystyrene in various forms should play an even more important part in the field of electronics.

Developments during 1940

The new uses of polystyrene take advantage of the same general characteristics and properties which have been utilized in the past years and include the following: transparent containers, such as those used for the R.C.A. Victor Long Life needles, new types of liquor pourers, saxophone reeds, a water- and chemical-resistant device for spreading heated medicated vapors through the respiratory tract, closures for chlorine bleaching solutions, stones for costume jewelry, certain novelty applications replacing imported cut glass objects, and vest-pocket pencil magnifiers. The cream colored instrument panel for small aircraft described above opens up an entirely new field for the material.

Considerable headway has been made in improving the physical characteristics of the final molded product. The impact, tensile and flexural strengths of polystyrene have been improved, producing a better molding material. Color and clarity have also been improved. The incorporation of luminescent materials in polystyrene is another important development this year.

The coaxial cables (metal tubes wire suspended in the center) insulated with interlocking polystyrene beads, are very widely used for high efficiency antenna lead-ins, for aircraft, television and frequency modulation. The power factor of the material is practically nil and water absorption approaches zero—both important factors in radio making. In radio receivers where the highest efficiency is desirable, tube sockets, coil forms and other insulating parts are molded from polystyrene. It is also supplied in liquid form and used as an insulating lacquer, or coating, on coils, condensers and as a shielding medium for ceramics.

Methods of fabrication

Injection molding is preferred, although small-production samples may be produced by compression.

Typical applications

Closures for acids, bases and bleaching solutions
Combs and novelties
Refrigerator parts, trim and panels
Liquor pourers and closures
High frequency, low loss radio and television parts
Signs and edge lighted letters
Cosmetic containers and closures
Colored light reflectors and indicators
Imitation jewels
Coaxial cable beads
Airplane instrument panels
Radio housings
Transparent containers
Magnifiers

Outstanding properties

Low specific gravity
High index of refraction
Excellent acid and alkali resistance
Excellent water resistance
Excellent dimensional stability
Low molding shrinkage
Excellent molded finish
Ability to carry light
Excellent electrical properties
Transparency

Trade names

Bakelite polystyrene, Styron (Dow polystyrene), Monsanto polystyrene

7



8



7—The lid of this R.C.A. portable radio which also serves as a housing for the antenna of the set is injection molded of Bakelite Polystyrene by Mack Molding Co. The material's stability and electrical properties recommend it for the purpose. 8—Attractive polystyrene salad bowl by Kilgore Mfg. Co. resists vinegar and fruit acids. Available in transparent colors for premium use

DURITE

Honored by Plastics Competition



DURITE proves its worth in the stiffest Modern Plastics Competition ever held. As the material used in the thermostat* molded for the Wilcolator Company, well-known manufacturers of heat control devices, it has been honored by the Judges of the 1940 Modern Plastics Competition.

The heat resistance and insulation, and great dielectric strength of DURITE molding material are put to good use in this honored piece. Contact casing, dial and two oven circuit controls have excellent surface finish. And they will never peel, chip, dent or fade.

Give your product the advantages of DURITE. Write to DURITE PLASTICS, the exclusive producers of phenol-furfural resins.

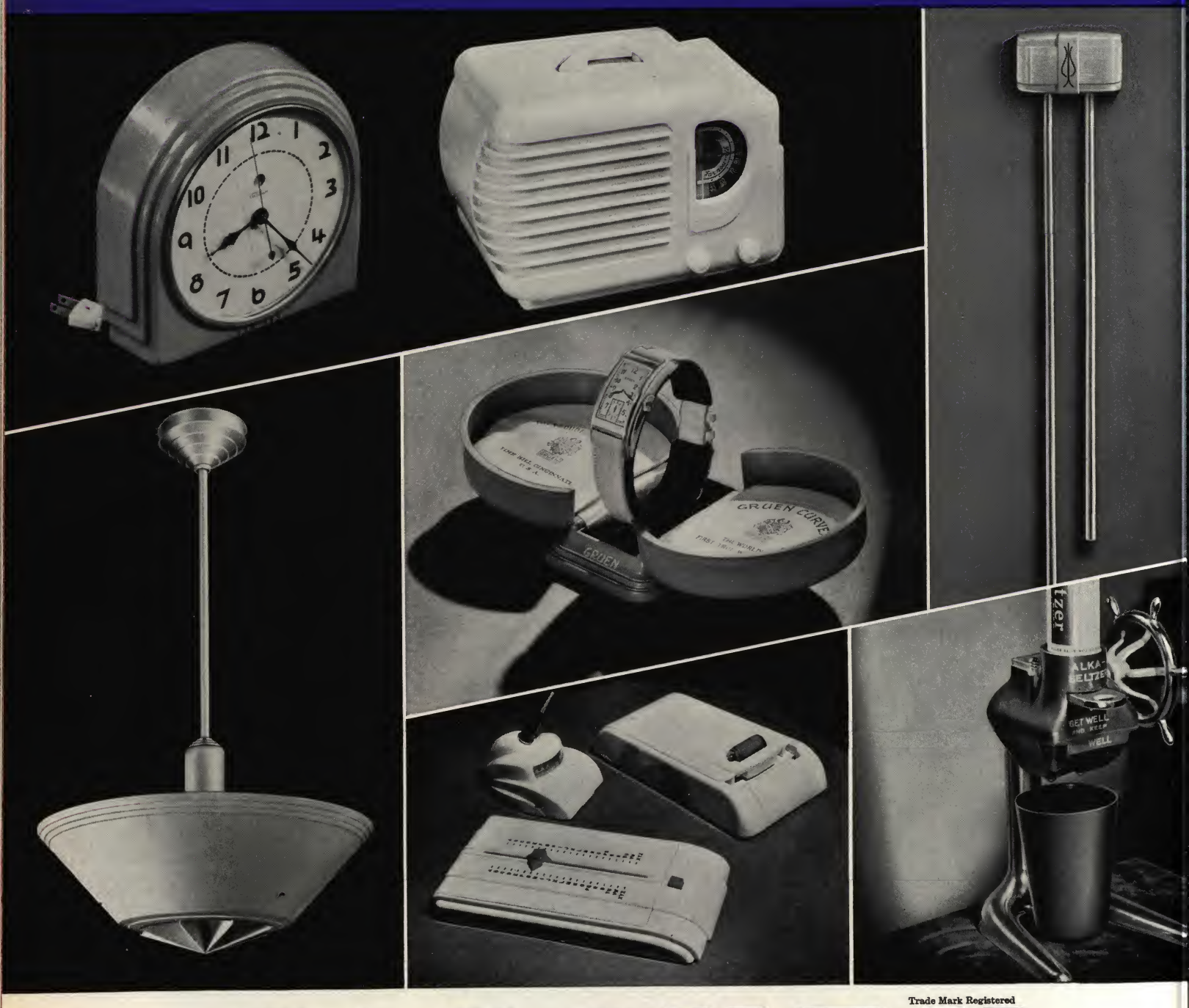
** Molded by Consolidated Molded Products Corp., Scranton, Penna.*

DURITE PLASTICS

REG. U. S. PAT. OFF.

FRANKFORD STATION, P. O., PHILADELPHIA, PA

Develop More Profitable Products



Trade Mark Registered

PLASKON

★ MOLDED COLOR ★

with PLASKON



PLASKON is one of the most beautiful materials . . . and one of the most practical . . . for meeting today's profit demands in manufacturing and merchandising.

Each day the distinctive features of Plaskon are utilized for the development of new and different products, incorporating advantages that are obtainable with no other material. The versatility of Plaskon Molded Color is shown on the opposite page by the products of several nationally-known manufacturers.

Plaskon is the world's largest-selling urea-formaldehyde plastic. It is supplied in powder form for molding by heat and pressure into an endless variety of shapes and sizes.

PLASKON FEATURES

1. PLASKON may be had in a wide range of beautiful colors—purest white, dainty pastels, brilliant hues, jet black.

2. PLASKON is solid molded color—clean, clear, permanent color. It retains its lustre, will not fade, and its color value is not injured by scratching or abrasion. Plaskon cannot rust, corrode or tarnish.

3. PLASKON MOLDED COLORS range from complete opacity to a high degree of translucence. When molded into lighting reflectors, Plaskon provides maximum illumination without glare.

4. MOLDED PLASKON is light in weight. Yet it has great strength, is shatterproof, will not chip and resists breakage.

5. MOLDED PLASKON is admirably adapted to the requirements of modern designing. It can be molded into almost any shape—from large housings for fixtures and appliances down to the tiniest buttons.

6. MOLDED PLASKON is sanitary—odorless, tasteless, inert. The surface is hard, smooth, easy to clean. Nor does it absorb odors or flavors. Molded Plaskon resists the effects of oils and organic solvents.

7. MOLDED PLASKON has an exceptionally low degree of heat transference and unusually high dielectric strength.

TYPICAL USES

BOXES . . . . for Jewelry and Watches
BUTTONS and BUCKLES
HOUSINGS . . . . . for Clocks, Radios, Scales and Appliances
CAPS . . . . . for Bottles and Tubes
CONTAINERS . . . . . for Cosmetics
COVERS . . . . . for Boxes and Jars
DIALS, ILLUMINATED . . . . . for Radios, Automobiles
DISPLAYS AND SIGNS . . for Outdoor and Indoor use
DOME and SIDEWALL LENSES . . . . . for all types of Transportation Vehicles
FITTINGS . . for Refrigerators and Electrical Appliances
HANDLES and KNOBS . . . . . for Radios, Electrical Appliances, Stoves, Cabinets, Fixtures, Automobiles, etc.
HARDWARE . . . . . Permanently Colored Trim
KEYS . . . . . for Organs and Pianos
PACKAGING . . . . . Color to Catch the Eye
REFLECTORS . . . . . for Lighting Applications
SWITCH PLATES, Receptacles and Other Electrical Wiring Devices
TABLEWARE . . . . . Dishes, Cups, Saucers, etc.
TOYS and NOVELTIES

The Plaskon Company conducts complete research into any problems involving new applications of Plaskon Molded Color. It includes aid in designing new products, as well as assistance in re-designing items already in production. It includes expert engineering opinion on design and on the methods of manufacturing finished products, as well as experienced counsel on the molding of Plaskon.

PLASKON COMPANY, INCORPORATED
2109 Sylvan Avenue, Toledo, Ohio • *Canadian Agent:* Canadian Industries, Ltd., Montreal, P.Q.

WORLD'S LARGEST SELLING UREA-FORMALDEHYDE PLASTIC

Coumarone-indene resin

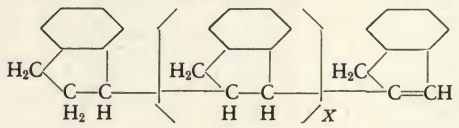
COUMARONE-INDENE resins are produced through polymerization and are among the first synthetic resins developed commercially in the United States. This class of synthetic resin had its beginning in the work of Kraemer and Spilker, who in 1890 isolated coumarone and indene from certain coal-tar light-oil fractions and polymerized them by sulphuric acid to form resins. This work bore fruit when further study of practical manufacturing methods resulted in the establishment in the United States during the World War of a commercial process for producing coumarone-indene resins.

Chemistry of their production

Among the coal-tar light oils recovered from by-product coking operations is that fraction distilling between 150 to 200 deg C. It is rich in indene, coumarone and homologous bodies including their methyl derivatives. The naphthas after suitable refining operations are treated by intimate admixture with small quantities of concentrated sulphuric acid to effect polymerization of the reactable constituents. The acid is settled and removed, any residue remaining is neutralized and the resinous components separated by distilling off the unreacted naphthas. The resin remains in the still. The

parent materials indene  and coumarone 

may be represented by the structural formulas shown above. The polymerization is assumed to be a chain reaction of the following general pattern:



Coumarone-indene resins plasticized with selected pitches and special processed oils are the tile base for this Kentile office floor of National Register Co. These resins are noted for their durability in such applications. (Photo, courtesy Barrett Company)



By regulating carefully the conditions of the reaction it is possible to produce a series of resins varying from semi-fluid viscous resins, to plastic and hard brittle grades and in color from dark brown to pale straw.

General characteristics

No property, probably, is of greater importance to the technician in the development of plastics, adhesives or coatings than that of the ready compatibility of the coumarone-indene resins with a wide variety of resins, polymerized bodies and plasticizers. In general, the various grades of this resin are relatively low in molecular weight (the hardest has an average value near 1000) and at temperatures above their melting points are completely fluid. These characteristics enable them to be utilized readily in modifying the properties of many other resinous bodies and compounds based on them.

In one industry alone several million pounds per year of the coumarone-indene resin are used because it readily blend with and supplements the properties of certain bitumens. However, a more vivid realization of the possibilities in various fields is gained through a survey of the many resins, waxes and bitumens which, under proper conditions, can be blended with the coumarone-indene resins (Table I). The wide range of solubility includes the coal-tar solvents, many petroleum thinners, esters, ketones, chlorinated hydrocarbons and cyclic alcohols and many vegetable oils.

Variations in the polymerization process whereby phenolic bodies participate in the reaction yield resins which are alcohol soluble to a considerable degree and more widely compatible than the conventional polymers. These resins are compatible not only with the same materials as coumarone-indene resins but blend with shellac, vinyl acetate polymers, urea-formaldehyde resins, aryl sulphonamide-formaldehyde resins and form stable compounds with up to 30 percent of cellulose acetate. They blend with nitrocellulose in certain ratios.

Cyclo paraffin resins

Catalytic hydrogenation of the coumarone-indene polymers yields a series of resins which are described as cycloparaffin resins. These resins are more compatible with paraffin waxes and with aliphatic hydrocarbons than the conventional coumarone-indene polymers although in other directions range of compatibility is narrower in scope. These hydrogenated resins are characterized by their pale straw to water-white color and by relatively greater stability to ultraviolet light than the coumarone-indene resin. Certain grades of this resin are compatible with isobutylene polymers.

(Please turn to next page)

RESIN and LACQUER PRODUCERS

IMPROVE YOUR RESINS BY USING "NATIONAL ANILINE"

TOXILIC (MALEIC) ANHYDRIDE—A uniform, white, chemically pure product of increasing importance as a raw material to producers of *quality resins and plasticizers.*

CHEMICAL SPECIFICATIONS

MOLECULAR WEIGHT	98
DENSITY	1.42 at 28° C
MELTING POINT	52.6° C
BOILING POINT	202° C

SOLUBILITY — Readily soluble in benzene, hydro-carbons, acetone, ethyl ether and chloroform.

PHTHALIC ANHYDRIDE—A standardized, pure white, flake product from production sources adequate to meet your every demand

OTHER RELATED CHEMICALS—In addition, the following chemicals are now available in commercial quantities: Succinic Acid and Anhydride • Malic Acid • Fumaric Acid • Toxilic (Maleic) Acid.

NATIONAL ANILINE & CHEMICAL CO., INC.

40 RECTOR STREET NEW YORK, N. Y.

BOSTON	150 Causeway St.	GREENSBORO	Jefferson Standard Bldg.
PROVIDENCE	15 Westminster St.	ATLANTA	140 Peachtree St.
CHICAGO	357 W. Erie St.	NEW ORLEANS	Masonic Temple Bldg.
PHILADELPHIA	200-204 S. Front St.	CHATTANOOGA	James Bldg.
SAN FRANCISCO	517 Howard St.	PORTLAND, ORE.	730 West Burnside.
CHARLOTTE	201-203 W. First St.	TORONTO	137-145 Wellington St., W.

BRANCHES AND DISTRIBUTORS THROUGHOUT THE WORLD

Recent developments

The great benefits accruing to the automotive, electrical and similar industries through the rapid commercial development of polychloroprene, polymerized butadiene and related rubber-like products have not been overestimated. Compounders working with these products have come to realize the value of the coumarone-indene resins as plasticizing agents and tackifiers of high efficiency.

In homes, hospitals, public and industrial buildings mastic floor tiling, much of which has been made with the coumarone-indene resin binder, has found increasing use over the past ten years. Mastic floor tile is suited for many locations not only because it is available in many attractive shades and marbleized effects but because such floors are quickly laid and easy to maintain. The average yearly output of mastic floor tile has grown to approximately 50,000,000 square feet.

The process for the manufacture of mastic floor tile is relatively simple. To produce tile-base the coumarone-indene resin is plasticized with various selected pitches or specially processed oils so that a binder satisfactory in physical properties and light in color is obtained. The binder and mineral fillers, including those of the fibrous type, with a smaller amount of granular material and pigment are thoroughly blended in mixing rolls or other standard type masticating equipment. A suitably prepared binder provides a mix which at temperatures above the melting point of this binder flows together smoothly. Thorough wetting of the filler due to fluidity of the binder at mixing temperature provides a dense plastic with good coherence. The plastic is sheeted through rolls, polished and cut into standard sizes.

Transcription records, so necessary to the radio industry, have been prepared from vinyl resins, including such types as polyvinyl acetals. The utility of the coumarone-indene resin is well demonstrated in its use as a flux with some of the vinyl resins to improve the milling and flowing qualities and to increase the fidelity of the plastic in reproducing the fine contours of the master mold. The records so produced are light in weight and have a minimum of surface noise.

So many possibilities exist for laminated products in industrial uses that an illustration of the use of the coumarone-indene resin in supplementing the properties of certain phenolic resins is worthwhile considering. Sheets of paper or paper board are saturated with the coumarone-indene resin from solvent solution. After drying the sheet is passed through a solution of oil-soluble phenolic resin. Two or more sheets so treated are laminated by heat and pressure. Thus the more expensive phenolic resin is partly replaced by the thermoplastic resin which blends with and forms a strong bond with the phenolic binder.

Forms available

Viscous liquids to high-melting solids
Color ranges from pale-yellow to dark red-brown or almost black

Typical applications

Mastic floor tile
Rubber compounding
Protective coatings
Transcription records
Paper impregnation

Outstanding properties

Acid, alcohol, alkali, brine and water resistance
High electrical breakdown
Low power factor (60 cycles at 80° C.—0.5–1.0% and at 2500 kilocycles at 21° C.—0.04%
Neutral reaction
Thermoplasticity
Non-saponifiability
Specific gravity of 1.08–1.14
Low viscosity in solution
Wide range of solubility

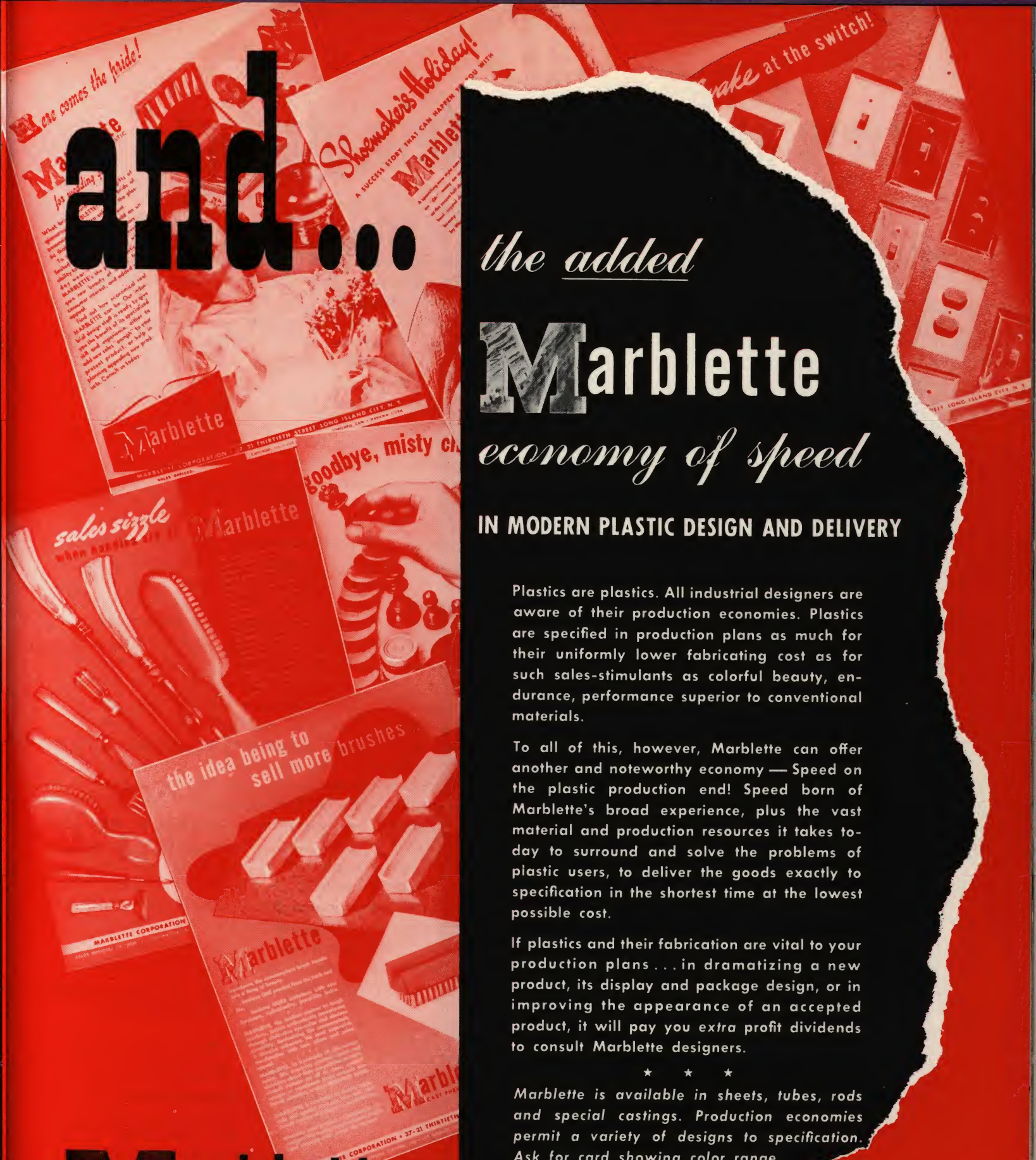
Trade names

Cumar, Nevindene

TABLE I. LIST OF PLASTICS COMPATIBLE WITH COUMARONE-INDENE RESINS

Waxes	Natural Resins and Derivatives	Synthetic Resins	Rubber	Bitumens
Beeswax	Batu	Alkyd (2)	Balata	Asphalt
Candellila	Congo (run)	Chlorinated diphenyl	Chlorinated rubber	Coal-tar pitch
Carnauba (1)	Rosin	Methacrylates	Chloroprene	Fatty acid pitch
Ceresin	Congo ester	Modified phenolic	Factice	Gilsonite
Halowax	Dammar	Oil soluble phenolic	Gutta siac	Pine tar
Japan	East India	Petroleum resins	Jelutong	Vegetable pitch
Lanolin	Elemi	Polystyrene	Polysulphide	
Opal	Ester gum	Vinyl (1)	Resinified rubber	
Spermaceti	Limed rosin		Rubber	
Stearic acid	Lead resinate			
	Zinc resinate			

(1) A small proportion of coumarone-indene resin (depending on the grade) may be blended with these.
(2) Long oil or rosin modified alkyd resins blend with the coumarone-indene polymers.



and...

the added

Marblette

economy of speed

IN MODERN PLASTIC DESIGN AND DELIVERY

Plastics are plastics. All industrial designers are aware of their production economies. Plastics are specified in production plans as much for their uniformly lower fabricating cost as for such sales-stimulants as colorful beauty, endurance, performance superior to conventional materials.

To all of this, however, Marblette can offer another and noteworthy economy — Speed on the plastic production end! Speed born of Marblette's broad experience, plus the vast material and production resources it takes today to surround and solve the problems of plastic users, to deliver the goods exactly to specification in the shortest time at the lowest possible cost.

If plastics and their fabrication are vital to your production plans . . . in dramatizing a new product, its display and package design, or in improving the appearance of an accepted product, it will pay you *extra* profit dividends to consult Marblette designers.

★ ★ ★

Marblette is available in sheets, tubes, rods and special castings. Production economies permit a variety of designs to specification. Ask for card showing color range.

Marblette
CAST PHENOLIC RESIN

MARBLETTE CORPORATION • 37-21 THIRTIETH STREET, LONG ISLAND CITY, N. Y.

SALES OFFICES: CHICAGO, ILL. • LOS ANGELES, CAL. • TORONTO, CAN. • HAVANA, CUBA

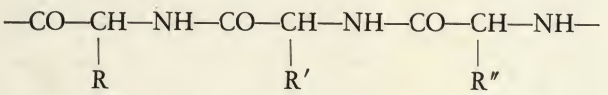
Casein and other protein plastics

THE main fact of general interest concerning the casein plastics is the source of the chief raw material, namely, milk. The casein, which is the protein portion of milk, can be precipitated in several ways, such as by heating or the addition of acids, but for the manufacture of plastics, casein obtained by the action of the enzyme rennet, is preferred. The early development of this plastic took place in Germany and can be traced back to the discovery reported in 1900 in U. S. Patent 646,844 by Spitteler and Krische that formaldehyde converts casein into a tough, insoluble, horn-like mass. Shortly afterward they adopted for their product the trade name "Galalith" from the Greek, "milk stone," and this to some extent has been used as a general term for casein plastics, regardless of manufacturing source.

According to statistics presented in a book on *Casein and Its Industrial Applications* by Sutermeister and Browne, published during 1939, the annual consumption of casein plastics in the United States as sheets and rods is 56 tons and the amount of casein plastics converted into buttons and buckles by the seven firms engaged in this business is between 4000 and 5000 tons annually.

Chemistry of the process

The last few years have witnessed more interest in and work done on the chemistry of proteins than has been the case since the days of Emil Fischer. Application of the x-ray to the study of protein structure has confirmed the earlier postulate of polypeptide chain linkage of amino acids to form proteins, thus:

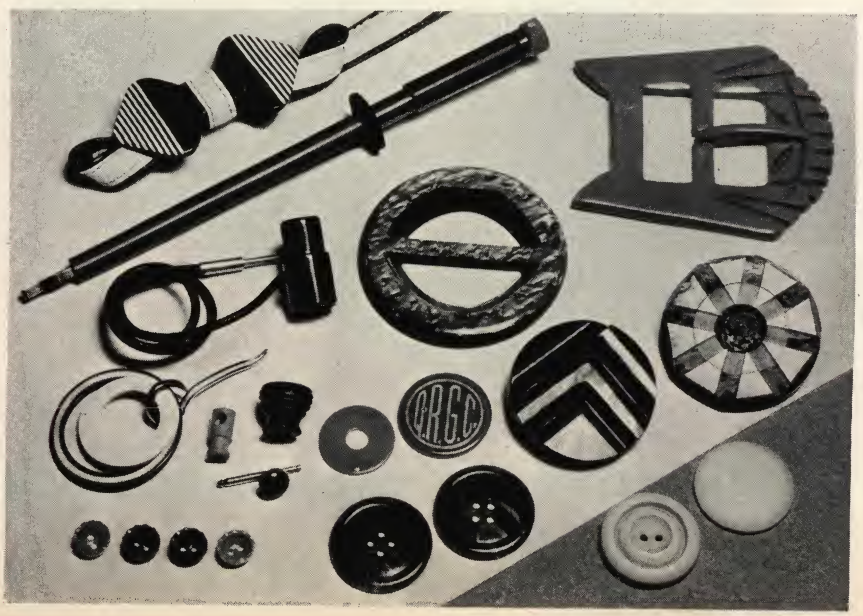


It has also demonstrated two distinct types of protein structure, fiber and globular, and has indicated that the difference lies in the fact that the side chains of the latter have inter-reacted to pull the protein molecule out of its natural fiber structure. Reactions of the protein molecule may be expected to take place in the side chains rather than in the backbone, except those reactions violent enough to break down the protein into its amino acid residues.

The most important reaction in the preparation of protein plastic material up to the present time has been the reaction with formaldehyde. Attempts to study this reaction by means of the x-ray were unsuccessful at first, probably owing to the large size of the protein molecule as compared to the small areas reacting and to the fact that proteins are not usually crystalline. Investigation of the reaction on the amino acids, lysine, arginine, and histidine, however, gave quite positive results. From these results it is reasonably certain that the methylene linkage, $—N{=}CH_2$, which has been frequently postulated, does not exist. It is further indicated that a cross linkage is probable, and this is confirmed in the examination of properties of protein-formaldehyde plastic which is inclined to be resin-like and brittle, a characteristic of polymers with cross linkages.

Much more work will be necessary before reliable information on this and other protein reactions can be properly understood. For example, zein, a prolamine, has no free amino groups, so, theoretically, it would not be expected to react with formaldehyde. However, some sort of reaction must take place, because zein after treatment with formaldehyde has been found, not more water-resistant as is the case with most proteins, but definitely much less water-resistant. What the reaction may be is not known at present. To many workers, the fact that the water absorption of zein is increased by the formaldehyde treatment is not known, as many methods for the preparation of plastic and film material from zein specify treatment with formaldehyde.

(*Please turn to next page*)



Ornamental Ameroid costume accessories are fabricated from casein rods or shaped arbors as shown by these products of American Plastics Corp. Endless color effects, the use of automatic machinery when necessary, make the material highly desirable for the clothing market

There's A NIXON PLASTIC For Your Purpose





NIXON ACETATE MOLDING POWDER—

Available in special compounds for both injection and compression molding. Comes in all colors, shades, tones, mottles. Each batch is completely uniform—as are re-orders of the same material.

NIXONOID: NITRATE SHEETS, RODS, TUBES—

Special care in manufacture, combined with the unique Nixon curing process, insures consistency of diameter and thickness through all lengths. Flat sheets are uniformly *flat*. Available in all colors, tints and mottles.

NIXONITE: ACETATE SHEETS, RODS, TUBES—

Complete range of colors. Uniformity through all lengths of rods and tubes. Flat sheets come flat, stay flat through special Nixon curing. All standard sizes.

NIXON PLASTICS

NIXON NITRATION WORKS, INC.

Mfrs: NIXON ACETATE MOLDING POWDERS • NIXONITE (acetate) and NIXONOID (nitrate) sheets, rods, tubes

NIXON • • • • • NEW JERSEY

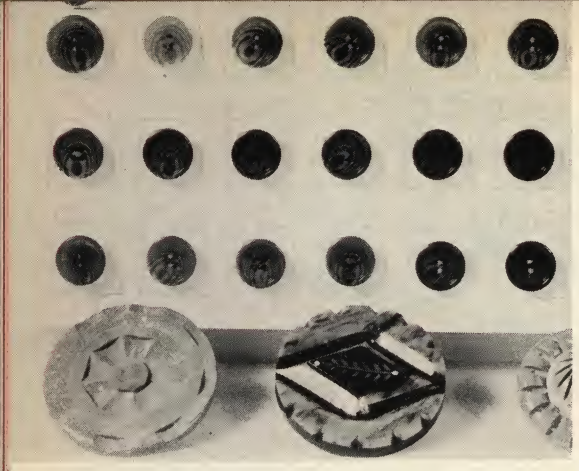
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MR C B JUDD
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phone Chestnut 8495

MR W S MOWRY
126 Marsden Street, Springfield, Mass.
phone Springfield 4-7121

MR T C McKENZIE
6432 Cass Ave., Detroit, Mich.
phone: Madison 5300

MR. A F PERRY
Leaminster, Mass.
phone Leaminster 1011



Galorn striated and novelty buttons are produced of casein in large quantities. These are by George Morrell Corporation

There is a large field for worth-while research investigating reactions other than with formaldehyde to produce material suitable for the production of commercial plastics, films, and fibers from protein. The protein-formaldehyde complex leaves much to be desired and is used merely because nothing better has been found. A reaction which appears well worth investigating is that of ketene or diketene with protein. Preliminary results indicate that this reaction, properly controlled, may produce a material of considerably more favorable properties than the protein-formaldehyde complex for the preparation of both plastics and fibers. There are other possibilities to be investigated and developed.

Manufacturing process—casein plastics

The following outline of the manufacture of casein plastics gives a general picture of their preparation, but no attempt is made to include details regarding the necessary precautions and chemical control that are required. The rennet casein is ordinarily supplied to the trade in the granular form as it comes from the drier. This is ground in a mill with corrugated rolls, such as are used in flour mills, or by impact pulverizers to pass a 40-mesh sieve with only a small percentage of fine powder which will pass through a 100-mesh sieve. It is then thoroughly kneaded in a dough mixer with about 40 percent of water and with coloring materials. The greater the proportion of water the softer the plastic and the greater the shrinkage on finishing. After admixture with water, the plastic must be carried through the next steps without delay. It is fed into a heated cylinder press fitted with a rotating screw and a nozzle with a bore of the desired size for the production of tubes and rods. The strength of the plastic is to a large extent dependent upon the mechanical working and macromolecular orientation which takes place during this operation. Sheets are ordinarily made by placing freshly extruded rods in frames of the desired size (usually 16 by 20 inches) and thickness, and pressing in heated hydraulic presses. Slicing sheets of the desired thickness from blocks of the soft plastic is an alternative method but is not in general use. The sheets, rods, and tubes of casein plastic so formed are hardened and converted into a compound no longer subject to putrefaction, by immersion in aqueous formaldehyde solution of 4 to 5 percent concentration for periods varying from 1 week to 6 months depending upon the thickness. Excess moisture and formaldehyde is then allowed to evaporate slowly to minimize formation of strains in the material with consequent cracking.

The time required for the complete formalization treatment may run considerably in excess of six months. A $^3/_4$–in. rod takes 241 days to cure with the time required for drying. Rods larger than $^3/_4$–in. are, therefore, no longer made. A 1–in. rod takes a year for both the curing and drying.

Warped sheets are straightened by pressing between hot plates and cooling under pressure. Rods are usually straightened by immersing in hot water and then forcing them into grooved straightening boards where they cool under pressure. Very special straightening of rods is done under hot plates, etc., but regular commercial straightening is not. All rods are ground to the required diameter. Occasionally they are polished if the customer pays for it, but polishing is not the rule. Sheets are rarely sanded, but are sold with the surfaces as they come from the sheet molds. Any sanding that is done is usually to roughen the surface for gluing.

General characteristics—casein plastics

All casein composition is hygroscopic and is therefore affected by atmospheric moisture changes. Experience has shown that sheet stock in sizes larger than four sq. in., has a tendency to warp.

It can be readily understood that pieces molded to shapes of varying dimensions and thicknesses would cure more rapidly in the thinner sections during the immersion in formaldehyde and would not maintain the desired shape. This difficulty has deterred the use of casein plastic as a molding material.

Casein plastic is made in a large range of opaque and translucent plain colors. Many mottled effects are also marketed. Originally these were principally imitation of horn, but now many different types are made, such as metallics, mosaics, pearl, jade, and other semi-precious stone effects. However, molding of casein is being done on items where close dimensions are not required.

It can be sawed, ground, cut, turned, and carved without difficulty and manufacturers equipped to work metal, wood, pearl, and similar materials find that much of their equipment can be used in the working of casein plastic. It is suitable for working on high-speed automatic or semi-automatic machines, and large quantities of articles are fabricated from casein rods on such equipment.

The fine and lasting polish which can be applied to casein plastic is one of the valuable features of the material. Formerly this was applied by smoothing the surface with powdered pumice stone and sawdust in tumbling drums or on rag buffing wheels and finishing with tripoli, wax, or rouge in tumbling barrels containing wooden pegs or by means of the rag buff. Now, the smoothed articles to be polished are placed in a hypochlorite bath heated to a maximum of 150 deg. F.; this treatment can also be carried out very satisfactorily with the solution at room temperature. After 2 to 5 minutes, the articles are removed from the bath, rinsed, and dried. The surface is soft when removed from the

(Please turn to page 105)

THRILLING NEW CHAPTERS ARE BEING CONSTANTLY ADDED TO THE STORY FOR

CATALIN

The Gem of Plastics



CATALIN and PRYSTAL
Cast Resins
CATABOND and CATAVAR
Liquid Resins
are registered trade marks

CATALIN'S greater beauty – the richer interpretation it gives to color–the extra sales appeal it brings to products–All have served our laboratories as a base from which to project variations–still more beautiful to the eye–still more interest-absorbing–and still more desirable to adopt.

As a result, *Catalin,* today, is augmented by *Aquapearl, Opalite, Prystal, Flitter* – their very names heralding the exquisite new effects they convey. Certain of our new *Technical Cast Resins* are being used by the process industries as linings for chemical tanks – for the making of non-corrosive pipe–and in the production of noiseless gears, etc.

By experimenting with *Catalin Liquid Resins*– and by applying the findings to exhaustive field tests, we now have–(1) . . . *Catavar*–a group of special varnishes whose qualities of translucency, color and durability commend their use to a wide field of lamination–(2) . . . *Catabond*–a group of special adhesives used for plywood and airplane construction – also for bonding abrasive wheels and discs–for impregnating cork, wood, etc.

Catalin, too, by its highly developed casting processes has kept pace–thus enabling it to satisfy an ever-broadening scope of product requirements. Without recourse to expensive molding equipment, *Giant Draw Castings* will eject lengths of 40 inches or more, shaped to exacting specifications. Three-dimensional *Split-mold Castings,* will, with undercuts, reproduce designs of intricate pattern. *Composite Castings* deliver two or three colors as a single, inseparable whole.

We therefore urge your further familiarization with any one or all of these economically adoptable new chapters. Inquiries will be given prompt and intelligent handling!

CATALIN CORPORATION

ONE PARK AVENUE · NEW YORK, N. Y.



Fairy Godmother to the Modern Cinderella

EVENING SHOE ILLUSTRATED IS A CREATION OF DALSAN, INC., DOLGEVILLE, N. Y.

CATALIN

THE GEM OF PLASTICS

THIS MOST beautiful of plastics is available in virtually any color—clear, translucent, mottled and opaque, It is non-inflammable, non-water absorbant, practically unbreakable and its color goes all through the material. It machines as readily as wood. * In addition to "Catalin", we supply a number of other plastics used in the fashion field today:—"Prystal", a crystal-clear material. "Aquapearl", an exquisite new plastic possessing all the depth and richness of the natural pearl; "Opalite", named for its resemblance to the fiery and ever-changing opal. We welcome inquiries from stylists, designers, and manufacturers.

"Catalin" is a registered trade-mark

GRACING HER loveliness with the magic of its beauty and the spell of its gem-like colors. * Literally, as in this instance, placing at her very feet the allure of a new enchantment... Catalin Heels! * Exquisitely conceived in clear, brilliant rainbow hues—these highly fashionable enhancements are available in all styles—in all sizes—and without recourse to expensive molds. * Catalin is a factor in the field of style. The public know it for the charm it brings to costume jewelry, dress accessories, toiletware... and countless other items of adornment and utility. They ask for it—by name—an asset that carries important selling significance!

* * *

CATALIN CORPORATION • ONE PARK AVENUE, NEW YORK, N. Y.


"Aquapearl"...A GLOWING ACHIEVEMENT
by CATALIN
THE GEM OF PLASTICS
IN AQUAPEARL, Catalin captures the subtle glow and exquisite beauty that are so exclusively expressive of the natural pearl.
Illusive, modulated highlights accentuate the charm of this colorful new gem. To the eye, Aquapearl is "life beneath the surface". Its deep-seated and ever-changing reflections are fascinating to behold.
The fine costume jewelry and decorative ornaments shown here illustrate Aquapearl's initial application—and mark its first presentation to the public. Rich, and untapped, are the opportunities! Write for details.
Aquapearl Handbag
by Deauville Bags, Inc., New York
Aquapearl Jewelry, designed by Martha Sleeper
for D. Lisner & Co., New York
CATALIN CORPORATION
ONE PARK AVE. • NEW YORK, N.Y.
Catalin and Aquapearl
are registered trademarks



CATALIN for Modern Handles

THE GEM OF PLASTICS

This Utility Model "Sweeper-Vac" with its colorful Catalin handle is "right at home" in the most luxurious surroundings! Along with its pre-eminently practical characteristics, Catalin brings its gem-like range of colors, its sleek, kind-to-the-hand finish and its inherent impression of Quality. ★ Catalin's incomparable beauty and durability are yours to use without expensive tool or mold costs and with the utmost economy in production. From its delicate transparent tints, through its mottled and translucent blends, to its deep rich opaque shades, Catalin remains strong, light in weight and strictly non-inflammable. ★ From dial knobs to door knobs; from kitchen cutlery to electric drills; from pots and pans to parasols — if it's "handled" with Catalin, it'll be handled with pride!

Catalin handle fabricated by
PLASTIC TURNING CO., Inc.
Leominster, Mass.
for the
SWEEPER-VAC COMPANY
Worcester, Mass.

★

CATALIN CORPORATION · ONE PARK AVENUE, NEW YORK, N. Y.

Catalin is a registered trade mark

CUTLERY..Now Stars in Stripes of CATALIN

THE GEM OF PLASTICS



"Americana" Cutlery, as introduced herewith. A set of 26 pieces—boxed as shown. A product of Englishtown Cutlery, Ltd., N. Y.

A patriotic salute to the American table—Cutlery Handles of Catalin—in the stirring red, white and blue, whose broad stripes are bright bars of sharply defined color—all three tones being achieved as a single one-piece casting...another stride forward in the development of Catalin's numerous new casting techniques.

Catalin, in this particular application, brings to the fore of importance its properties of structural strength, non-inflammability and non-absorbency of oils, grease and food stains. Ever inspiring and ever true to the colors is the eye-appeal of its brilliant, smooth, gem-like surface.

CATALIN CORPORATION • ONE PARK AVE., NEW YORK



New Worlds for Old
WITH CATALIN

THE GEM OF PLASTICS

Radio time and accurate time have become synonymous in the modern household. In the new "Radio-Numeral Clock" shown above, Anthony Martinek Devices have smartly combined an efficient receiver and synchronized timepiece in a Catalin cabinet of simplicity, charm and unusual acoustical properties.

Catalin cabinets, like all Catalin adaptations, have a beauty all their own. Their limitless range of colors appeals to the designer and decorator. Their economical cost of production and ease of manufacturing have won the approbation of Industry. And their brilliant, enduring finish and "quality" atmosphere have earned for them an enviable place in our American homes.

When YOUR product sallies forth to conquer brave, new worlds, clothe it in Catalin! We'll be glad to show you how.

CATALIN CORPORATION
ONE PARK AVENUE · NEW YORK

Catalin is a Reg. Trademark



A Study in Harmony

WITH

Catalin

THE GEM OF PLASTICS

CATHEDRAL CHIMES, by Edwards & Company, Norwalk, Conn. Mellow are its signals and new is the note it sounds in home decoration. To complete the effect of a perfect harmony, the housing is designed of richly colorful, brilliantly polished, gem-like Catalin. The graceful contours, set-backs and hollow interior are achieved by a simple draw casting. This and others of Catalin's highly developed inexpensive methods for the production of housings merit your investigation.

CATALIN CORPORATION
ONE PARK AVENUE, NEW YORK, N. Y.

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Catalin presents

CATABOND

NO. 630

A SUPERIOR NEW RESIN FOR ABRASIVE DISCS

as adopted by the

ALBERTSON & CO., INC.

CATABOND No. 630 joins the ever-widening range of Catalin liquid resins developed to do a better job of impregnating, laminating and bonding.

Exhaustive laboratory and field tests have proven conclusively that the "Sioux" Abrasive Discs manufactured by Albertson & Co., Inc., Sioux City, Iowa, employing CATABOND No. 630 as the bonding agent, are superior in every respect. Whether used for grinding welds, removing old paint from auto bodies or smoothing fenders, their flexibility, toughness, and non-loading qualities make for faster, cooler cutting and longer, more economical life. Furthermore, the use of CATABOND No. 630 renders these discs impervious to climatic conditions, water and moisture. They may be efficiently used for any and all sanding operations.



Catabond **and** ***Catavar*** **liquid resins, and** ***Catalin*** **and** ***Prystal*** **cast resins, are registered trade marks for products of the**

CATALIN CORPORATION

ONE PARK AVENUE, NEW YORK, N. Y.

(*Continued from page 96*) bath but sets to a glaze upon drying. This latter development is of particular importance to the firms manufacturing buttons from casein. Not only is the "dip polish" considerably less expensive than wax polishing in tumbling barrels, but the finish produced stands up under the conditions of cleaning and pressing used in most dry-cleaning establishments in the United States.

Developments during 1940

Casein: No outstanding developments were made in the manufacturing of casein plastic or its application. Except for the development of some new colors and color effects, nothing has been done to improve the material or the process of manufacture of casein plastics for several years. Buttons picked at random from samples representing the products of three different casein plastic button manufacturers absorbed 14.8, 19.7 and 12.6 percent water by the 24-hour A. S. T. M. method.

Soybean: Except for a small amount of solvent-extracted soybean meal which is added to a phenolic molding powder, there is no soybean protein plastic material in commercial production. However, a considerable amount of research and development work has been done with this material, much more than with casein plastics in recent years. A thermosetting soybean meal-phenolic molding plastic, containing equal parts of formaldehyde-hardened soybean oil-free meal, phenolic resin and wood flour, has been developed that absorbs only 3.0 percent water by the same A. S. T. M. test described above for casein. One company developing a soybean-phenolic molding powder claims to have one which they expect to use on the Lauterbach rotary automatic machine for molding bottle caps. They also claim to have developed a soybean-phenolic molding plastic for phonograph records with good tone quality.

A molding powder made up of equal parts of formaldehyde-hardened soybean oil-free meal, phenolic resin and wood flour has been found to be completely thermosetting, to cure as rapidly as regular phenolic molding powders, to be nearly as strong by flexural and impact strengths and to dye much more readily to light shades of red, yellow or green because of the comparatively large percentage of protein. This protein causes the water absorption to be about 3.0 percent for 24-hour immersion, as compared to 0.5 percent for the straight phenolic plastic.

It is possible to prepare a laminated plastic by dipping a fibrous material, such as unsized kraft paper, in a dispersion of soybean protein in formaldehyde, drying to about 12 percent moisture content, and uniting in a heated press. A board results with about the same rigidity and strength as phenolic laminated, although it is not equal in water resistance.

Zein: Some work has been done on the development of zein, the prolamine from corn, into a plastic or a film material. This can no doubt be done if, and when, two rather serious handicaps have been overcome. Zein works up easily and well into a plastic and has, without any treatment, about the same permanence and water resistance as formaldehyde-hardened casein. However, zein is yellowish in color and its cost of extraction is so high that it must sell for 20 to 25 cents a pound. This price makes it prohibitive for any application found to date. If the cost could be lowered and the color lightened, there is no question but that zein would find a commercial application in plastics.

Forms of casein plastic available

Sheets—Standard size 16 by 20 in. by 2, 3, 4 and 6 mm. in thickness. Other thicknesses up to 12 mm. are made to order but sheets are not made thinner than 2 millimeters.

Rods—Available approximately 42 in. long and in diameters from $1/4$ in. to $5/8$ in., inclusive, in a large range of colors. Some colors are available in $3/4$ in. diameter. Rods as small as $1/16$ in. in diameter are produced by grinding $1/4$ in. rods to the desired size.

Tubing—Made to order in small diameters. The diameter is ground to the desired size but the bore cannot be held to accurate dimensions.

Disks—Cut to practically any desired size from $3/8$ in. to $2\,1/2$ in. in diameter. As a rule they are not cut thinner than 2 mm. or thicker than 6 mm. Miscellaneous shaped pieces punched from flat stock are also made to order for specialized fabrications.

Methods of fabricating casein

Chemical hardening: Button blanks, etc., formed from casein are immersed in formaldehyde solution to make the plastic hard and durable.

Machining: Articles are cut or ground to desired shapes from sheets, rods and disks.

Typical applications of casein

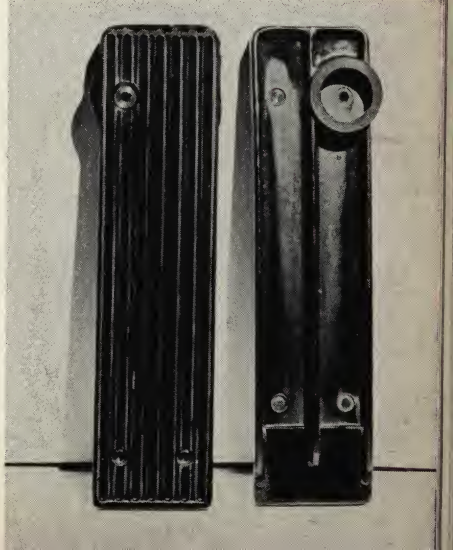
Buttons
Buckles
Beads
Game counters
Novelties
Trimming accessories

Outstanding properties of casein

Colorability
Non-flammability
Ease of polishing
Ease of machining
Hygroscopicity

Trade names for casein plastics

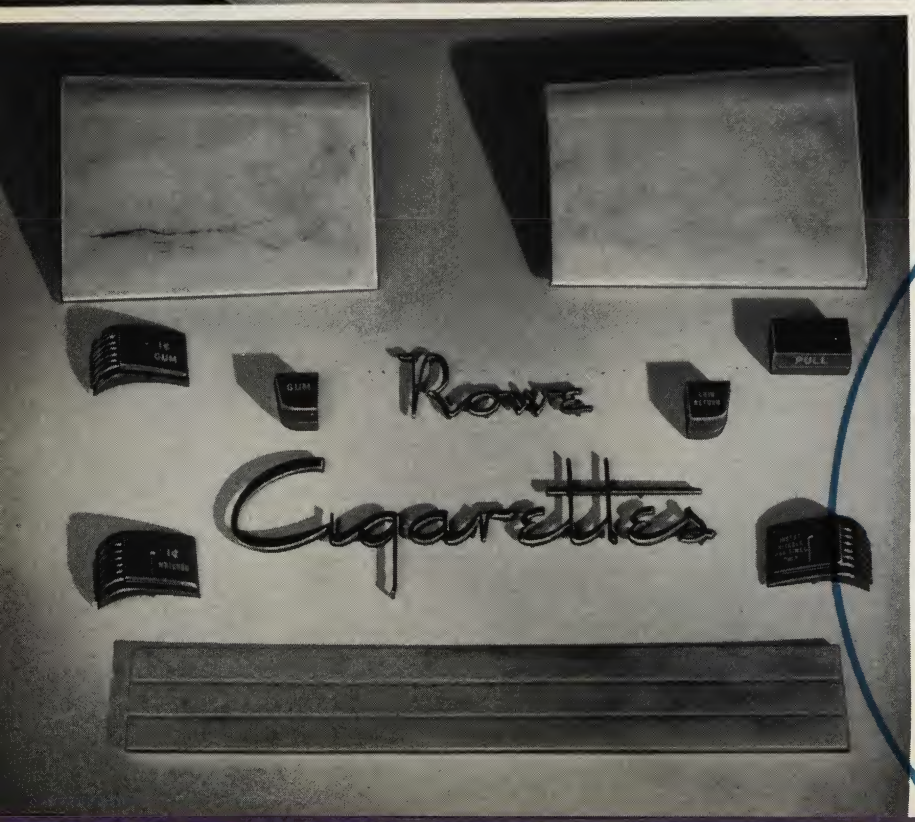
Ameroid, Gala, Galorn



Foot accelerator pedals are produced on a large scale by Ford Motor Co. from soybean derivative molding compound







In the Monsanto Plastics family there are six basic materials—ready to tackle any molding or fabricating job . . . ready to bring new color, richness and durability to your product . . . ready to increase sales appeal, aid in reducing production costs.

Recent applications of some of these materials are shown here and on succeeding pages, together with a brief description of the plastic used. For further information on any of these or other Monsanto Plastics, inquire: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield, Massachusetts. District Offices: New York, Chicago, Detroit, St. Louis, Birmingham, San Francisco, Los Angeles, Montreal.

CAST PHENOLIC RESIN

Monsanto Cast Phenolic Resin is an unusually brilliant and attractive material, hard and durable. It is non-inflammable, practically inert and has an exceedingly low rate of moisture absorption. It can be supplied in an infinite range of colors, simulating onyx, marble or similar finishes, or in solid colors ranging from crystal to jet black, in opaque, transparent or translucent effects.

Easily machined, Monsanto Cast Phenolic Resin lends itself to the low cost production of a wide range of products, from small buttons to radio cabinets, from clock cases to trim on furniture and transportation equipment. Furnished in sheets, rods or tubes or in special shapes cast as closely as possible to the finished form, it can be finished like wood or brass—sawed, turned, engraved, drilled, tapped, embossed—and has a high and lasting glossy finish.

Left above: **New Emerson radio cabinets fabricated from Monsanto Cast Phenolic Resin by Ortho Plastics Novelties, Inc., New York City.** ***Center:*** **These new pen sets of the W. A. Sheaffer Pen Company have attractive bases of Monsanto Cast Phenolic Resin.** ***Below:*** **Cigarette and Candy Vending Machines made by the Rowe Manufacturing Company, Inc., Belleville, N. J., have domes and mid-sections of Monsanto Cast Phenolic Resin, fabricated by Ortho Plastics Novelties, Inc., New York City.**

MONSANTO PLASTICS
SERVING INDUSTRY . . . WHICH SERVES MANKIND





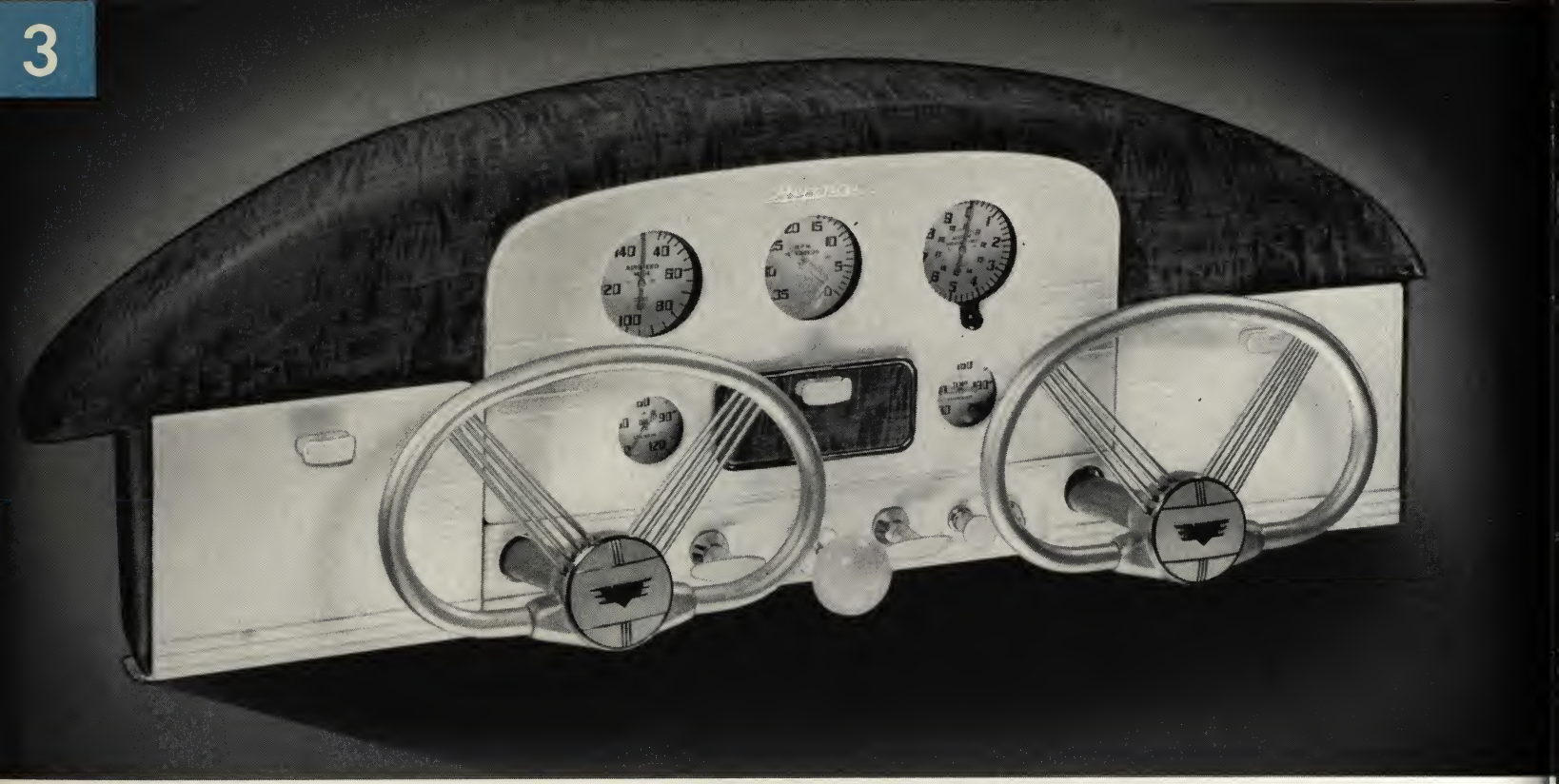


Left: The usefulness of Resinox lends itself to the fabrication of scores of widely different products. *Right above:* Completely molded in three pieces by the Boonton Molding Company, Boonton, N. J., this Scott tissue towel dispenser is an example of the versatility of Resinox. *Right below:* Colorful, durable bottle closures, molded from Resinox.

RESINOX

Resinox phenolic molding compounds have a flexibility of formulations which permits the compounding of special materials for specific applications. For instance, they are used in the manufacture of radio cabinets to add eye-appeal; in bottle closures, where the composition must withstand the chemical action of the contents without loss of torque strength; in working parts of motors or electrical equipment where such qualities as strength, heat resistance, accurate dimensions and durability are paramount.

Available in a variety of opaque colors or mottles that provide permanent finish without painting or lacquering, Resinox compounds afford rapid low cost production of articles, requiring very little finishing. Yet there is no sacrifice of quality, for every mold will give an unlimited number of pieces of exactly the same dimensions, with faithful reproduction of every detail.



POLYSTYRENE MOLDING COMPOUNDS

Monsanto Polystyrene has exceptional qualities that afford possibilities for the use of plastics in hitherto untouched fields. For example, its non-interference to radio frequencies makes it practical for use in tubes, grills and other parts. It is second only to fused quartz in electrical insulation qualities.

Monsanto Polystyrene is odorless, tasteless, non-toxic. It is unaffected by alcohol, resistant to acids and alkalies, impervious to water and humidity. Its clarity is unsurpassed by any other plastic. Colorless formulas of the material pass more than 90 per cent light, such flawless clarity making possible striking colors of every imaginable hue... in brilliant tones, pastel shades and countless configurations. It can be either injection or compression molded, forming in a single operation complicated articles of beauty, rigidity and hardness.

Above: This instrument panel on the Aeronca sports airplane has trim molded of Monsanto Polystyrene by the Metal Specialty Company, Cincinnati, Ohio, and Thermo-Plastics, Inc., St. Clair, Michigan. *Left below:* The exceptional qualities of Monsanto Polystyrene made it the only practical plastics material for this Diathermizer Inhalant, molded by Allied Plastics Corporation, Los Angeles, for the Diathermizer Corporation, San Francisco and New York. *Right below:* These dresser sets were molded from Monsanto Polystyrene by Plastic Molded Arts, Inc., Brooklyn.





NEW TYPES OF MONSANTO PLASTIC SHEETS

Monsanto sheet plastics have opened up a whole new range of industrial and display applications for plastics. Among these are:

Fluorescent acetate plastic sheets, in red and green, can be bent, cut, rolled or twisted into unusual shapes and designs. They have a strikingly luminescent quality that absorbs ordinary light and gives off a neon effect.

Flexible sheets of Monsanto Cellulose Acetate with special finishes and special pigmentations provide an ideal degree of light diffusion and light transmission. Used primarily in connection with fluorescent lighting fixtures, these diffusing panels can be embossed or colored, increasing the beauty of the fixture.

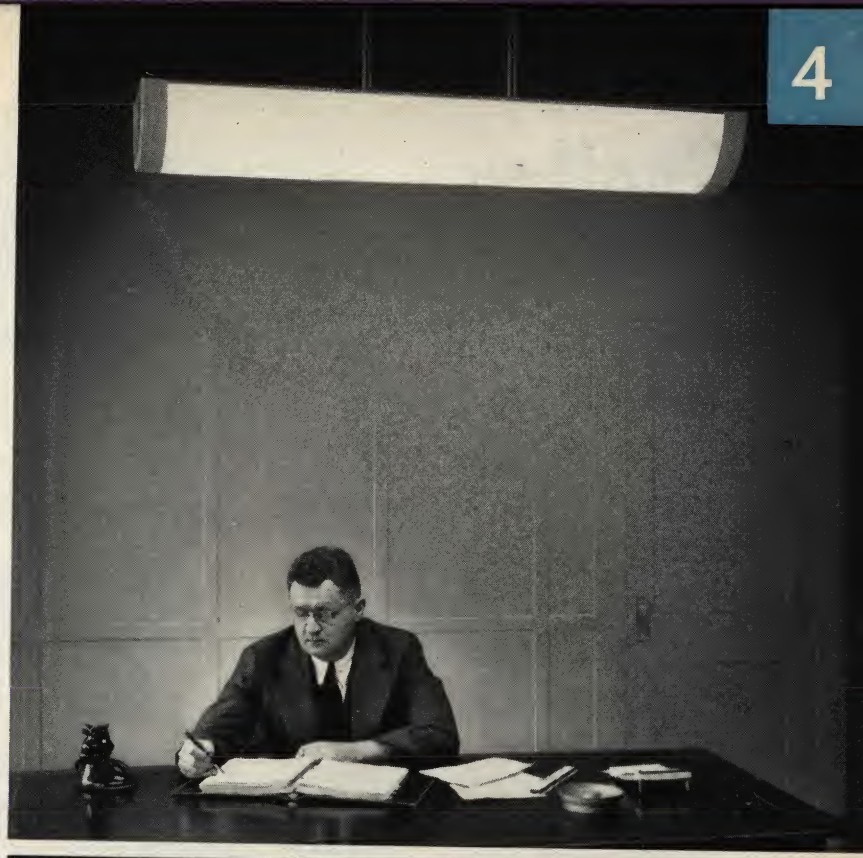
Similar to these diffusing panels are embossed acetate sheets, available in any number of intrinsic designs and colors, opaque, translucent or transparent. These embossed sheets can be cut or bent into special effects for any number of display purposes.

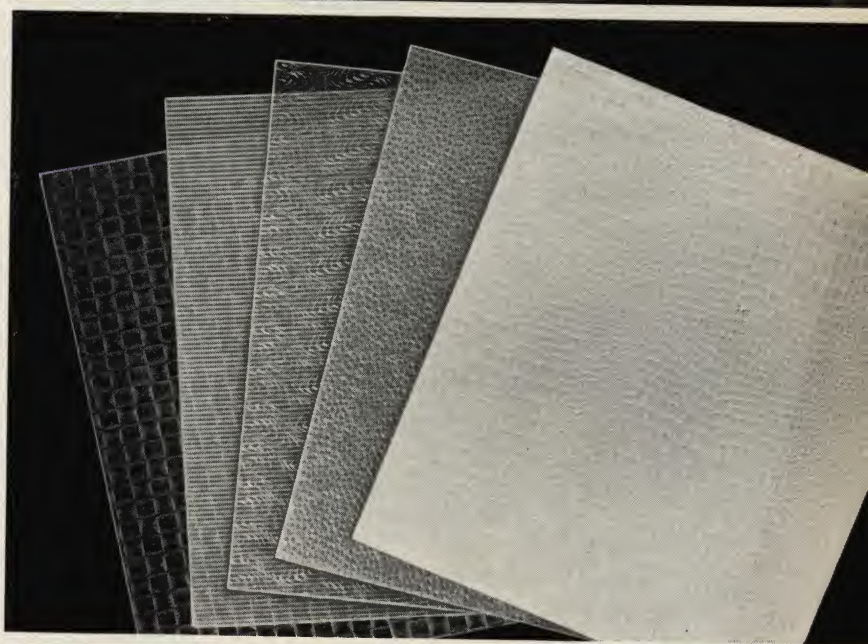
In addition, Monsanto produces all the standard types of cellulose acetate and cellulose nitrate sheets, rods and tubes.

MONSANTO PLASTICS

Cellulose Acetate • Cellulose Nitrate
Cast Phenolic Resin • Vinyl Acetal • Polystyrene
Resinox Phenolic Compounds

Sheets • Rods • Tubes
Molding Compounds • Castings
Vuepak Rigid Transparent Packaging Materials







Right above: The Miller Company, Meriden, Connecticut, uses Monsanto Acetate Sheets as diffusing panels for its line of fluorescent lighting fixtures. *Center:* These embossed sheets of Monsanto Cellulose Acetate are finding many applications for display purposes. *Below:* W. L. Stensgaard & Associates, Chicago, have used Monsanto Fluorescent Plastics in displays for such firms as Jantzen, Hickok and Saks-Fifth Avenue.



Shellac

SHELLAC, the flaked form of commercial lac, is obtained from a resinous incrustration secreted by the scale insect, *laccifer lacca Kerr*. This insect is a habitant of India. The resin, which it produces, has been used as a plastic from the earliest of times. Berliner employed it in 1890 for flat disk phonograph records. It was first used extensively for molded electrical insulation about 1900, and is still the only organic plastic binder used for very high voltage insulators.

Chemical composition

This resin is not a chemical entity. It is a solid solution of several different chemical compounds of somewhat similar structures. None of these compounds are truly resinous when obtained in fairly pure state.

The glands located in the skin of the insect produce two types of materials, a hard and soft resin when secreting the raw lac. The harder portion of lac, now known commercially as hard lac, has been separated in the laboratory into four individual fractions. The largest of these, 40 percent of the hard lac, appears to be composed of monobasic-interester-acids having the compositions represented by $C_{32}H_{54}O_9$. Equal molecular proportions of aleuritic acid, $C_{15}H_{28}(OH)_3COOH$, and a mixture of very similar acids containing a large proportion of shellolic acid, $C_{13}H_{16}(OH)_2(COOH)_2$ have been isolated from these interesters. The next largest fraction, 20 percent of the hard lac, contained monobasic-interester-lactone-acids of the composition $C_{15}H_{24}O_5$. These interesters were comprised of three acids: aleuritic acid, shellolic acid and kerrolic acid, $C_{15}H_{27}(OH)_4$-COOH and their isomers. The other 40 percent of the hard lac contained similar interesters of hydroxy acids. Some of these interesters apparently have molecular weights up to 1500.

The soft resin as it is obtained by solvent extraction has a semi-liquid consistency. This portion of lac acts as a natural plasticizer along with the wax. One fraction of it contained only a mixture of uncondensed hydroxy acids of which aleuritic and shellolic acids were found in the greatest proportions. The rest of the soft lac contained simple condensates of aleuritic acid, an isomer of the same and shellolic acid. Natural yellow dyestuffs and wax comprise the balance of pure shellac.

General characteristics

Shellac possesses a certain peculiar combination of physical properties which make it an ideal plastic binder for a wide variety of applications. It has a relatively low dielectric constant and excellent adhesive or bonding qualities for use with fillers such as flaked mica or asbestos to produce products of particularly excellent electrical properties. It is also a unique plastic resin in exhibiting characteristics of both the thermoplastic and the thermosetting types of binders. The long period wherein it remains thermoplastic when heated is a marked advantage in the manufacture of certain articles. Heat-curing increases the mechanical and electrical strength. Paper-laminated cylinders, for example, are cured at 300 deg. F. for several hours to develop their best properties for various electrical uses.

The greatest advantage of shellac plastics for electrical insulators is, however, their property of resisting carbonization. The gases generated when an electric arc strikes the insulating material are poor conductors of electricity and tend to turn the arc away from the composition. Shellac insulators are not as fragile as porcelain ones, and do not shatter when struck. They are also uniform throughout. Chipping or cracking the surface does not impair their usefulness to the same extent as it does with the ceramic types which depend upon a glaze for imperviousness.

Laminated compositions can be prepared by coating the paper or fabric with molten resin obtained by dusting it upon the fabric as it passes over a hot plate, or by coating it with an alcoholic solution, or with an aqueous varnish made by dissolving the lac in an alkaline solution. Shellac compositions have excellent thermal insulating properties.

The resin is compatible with thermosetting binders such as phenol-resins and alkyds. Mixtures of lac and phenol-resins are used in the manufacture of electrical

1 2 PHOTOS. COURTESY RCA VICTOR





1—Shellac, one of the earliest molding compounds of natural origin, is still used to manufacture disk records as on this tilting head compression press. 2—The records are given a final polish on simple finishing machines

Beautiful Gemstone

. . . The Fire of Rare Gems
. . . The Patina of Old Ivory
. . . The New Pearl Effects

CAST IN ANY FORM YOU NEED!





The rich brilliance and fine lustre of GEMSTONE, and the possibility of casting it into any form needed, make it the ideal material for use in brush handles, toys and games, knobs, radio and automotive parts and almost any other product where permanent beauty is essential.

It is available in all standard-sized sheets, rods and tubes; as well as a great variety of stock shapes such as balls, blocks. It can be machined readily to any finished form. Color and mottling can be rigidly controlled to any specification.

Immediate delivery on stock shapes and colors. Special orders receive prompt attention. Write for full particulars and samples.

A. Knoedler Company | **LANCASTER Pennsylvania**

insulators which are to be employed at intermediate voltages. The properties of such mixtures depend upon the relative proportions of the two resins. Those high in lac have good carbonization resistance, while those high in the phenolic resin show a rapid rate of cure and a high resistance to deformation by heat.

The properties of high scratch hardness and resilience make shellac an invaluable binder in the manufacture of phonograph records, especially where an accurate reproduction of over-tones is important as it is in the recording of classical music and speech. Shellac compositions also possess the valuable properties of giving a soft plastic mass which can be readily worked at temperatures of the ordinary steam-table. In pressing these compositions, they have an unusual evenness and smoothness of flow. They also take a very clear impression. Molded pieces have a high gloss and a hard surface. Wood-pitch is used as the common plasticizer. The price of these compositions is generally relatively low.

Recent developments

Research has developed several new technical methods for employing shellac. One of the most interesting of these is a special gun for applying shellac by the hot spray process. This technique of spraying molten lac has been successfully applied to the treatment of paper, canvas and jute in producing laminated electrical insulating tubes and boards for special purposes. The speed with which the lac can be applied in this manner has much to recommend it for such plastic uses.

Many of the drawbacks encountered in producing compression moldings of shellac compositions can now be overcome by employing the more recent types of injection molding machines, where small pieces can be produced at a relatively high production rate.

Combining lac with urea and other chemicals not only increases the rate of polymerization, but has been shown to improve the impact strength, heat resistance and water resistance of the molded articles. Other improvements have been obtained by removing the soft-lac. Extraction of as little as 3 percent will produce a resin which will not green copper. Hard-lac shows greater water resistance, a 20 deg. higher softening point and films can be baked without causing blisters or pin-holes. Shellac molded articles are now made having softening temperatures above 212 deg. F. where formerly the same articles showed tendencies to deform below 170 deg. F.

Removal of wax improves the properties which can be obtained when shellac is incorporated in rubber. Lac has been shown to have no deteriorating effect when so incorporated but certain modifications in vulcanization are necessary. Its use has been greatly extended in this part of the plastic field. Various other modifications of lac are also being studied. Many products with new properties have been developed in the laboratory. A wide variety of colored objects can be easily made.

Forms available

Lac is not sold in forms available for molding but only as a resin for making molding composition.

The most common forms of lac are: Shellac (flakes), button-lac (flat disks), garnet lac (dewaxed slabs), needle-lac and powder (bleached lac and dewaxed orange lac). It is also sold as alcoholic varnishes, or dissolved in alkaline aqueous solutions. Colloidal dispersions are used as hat binders.

Methods of fabrication

Compositions can be prepared by any of the methods common to preparing plastic compositions.

Molding: Compositions are usually softened upon a steam table at 225 deg. F. to 250 deg. F. They are molded at 250 deg. F. to 275 deg. F. and from 1000 to 3500 lbs. per sq. inch. Molds are chilled to 90 deg. F. to 120 deg. F. before releasing the pressure.

Injection molding can be carried out at 230 deg. F. in 1 to 2 min. for many pieces.

Typical applications

Electrical insulation (various types)
Thermal insulating board
Phonograph records
Protective coatings
Adhesives

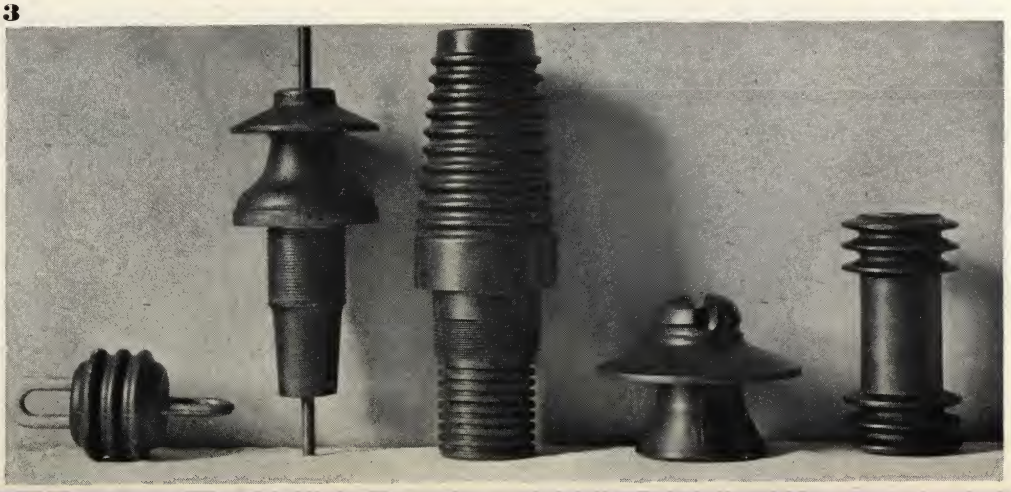
Outstanding properties

Low dielectric constant
High dielectric strength
Arcing resistance
Adhesion
Hardness
High gloss
Resilience
Low thermal conductivity
Ease of molding
Ability to wet fillers
Oil resistance when cured

Trade names

Complac, *Compo-site*, *Harvite*, *Lacanite*

3



3—Shellac insulators, resistant to carbonization, molded by Insulation Mfg. Co., have an important place in the electrical industry because of relative high strength and dimensional stability

Fine Chemicals
FOR FINE PLASTICS

FORMALDEHYDE U. S. P.
37% by weight • 40% by volume
A water-white solution of full strength and high uniform purity.
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Powder • Small Flo-Granules
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HEXAMETHYLENETETRAMINE
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U. S. P. and Technical

PENTAERYTHRITOL
Purified and Technical
A white, crystalline powder, non-toxic and conforming to standard specifications.

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——— Offer unusual opportunities to Industrial

——— Users requiring flat sheets of

——— Hard—Strong—Water Resistant Material

——— Available up to 1″ in thickness

Information concerning these materials may be obtained without obligation by addressing inquiries to—

Benaloid Division MASONITE CORPORATION
111 W. Washington St. Chicago, Ill.

FOR TOUGH MOLDING PROBLEMS USE

Ethocel

IT CAN BE-

EXTRUDED

INJECTION MOLDED

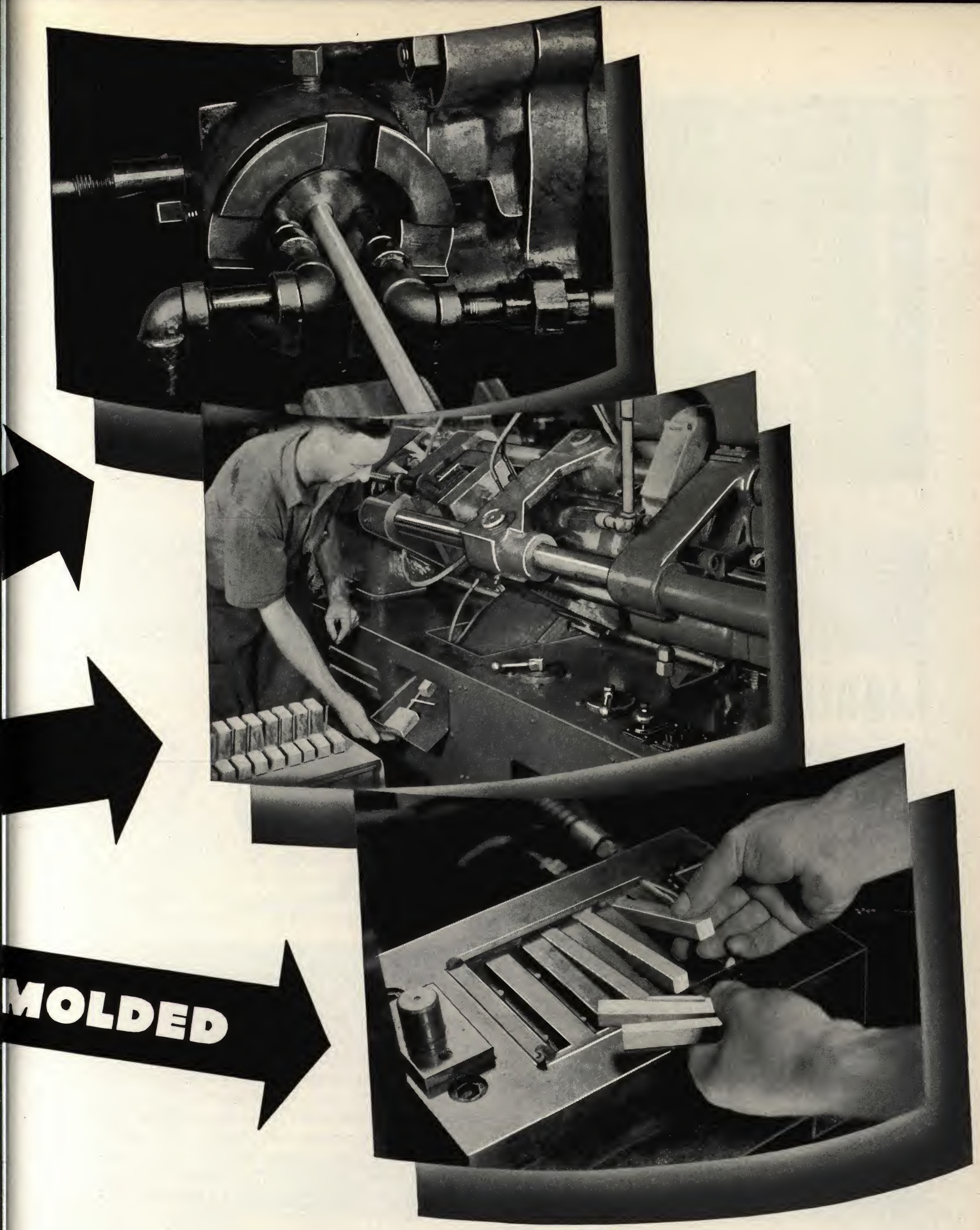
COMPRESSION

ETHOCEL* Plastic resists weather, light, heat and aging, molds with a high gloss and retains its finish under ordinary conditions. ETHOCEL Plastic supplies the molder with a wide range of light-stable colors. Besides being available in the usual commercial grades, ETHOCEL Plastic is also produced in extra tough grades for special jobs.

Dow is in a position to make recommendations as to capable extrusion molding companies, as well as suitable adhesives, buffing compounds and wipe-in inks.

For complete information on the wide variety of applications for ETHOCEL Plastic, as well as specifications and prices, write to the Cellulose Products Division, The Dow Chemical Company.

*Trade Mark Reg. U. S. Pat. Off.



THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

Branch Sales Offices: **New York, St. Louis, Chicago, San Francisco, Los Angeles, Seattle**



1



2

1—Lignin plastic panels being removed from press after cure. They have a high gloss finish. The thickness may be adjusted within broad limits. 2—Benalite, cured lignin plastic, manufactured by Masonite Corp. in panels 4 ft. by 12 ft. by 1/10 in. to 1 in., is excellent construction material

Lignin plastic

WOODY materials used in the manufacture of industrial products may be roughly classified as extractives, hemi-cellulose, cellulose and lignin. The extractives include water solubles, turpentine, rosin, tannins and similar materials, and may be ignored for the purpose of the present discussion.

Hemi-celluloses are present to roughly twenty percent of the remaining material. These are the wood sugar anhydrides, divided as hexosans and pentosans, and are convertible on acid hydrolysis to the corresponding sugars, which are water soluble. In the explosion process as described later, these are hydrolyzed and removed, leaving only the more resistant portion for manufacture of boards and plastic products.

Cellulose comprises about half of the woody substance and is the fibrous portion. Cellulose is the prime constituent of paper, and the highest quality papers consist essentially of pure cellulose. In the growing tree or plant, the cellulose is cemented together by the lignins and probably to some extent by the hemi-celluloses.

Lignin comprises about thirty percent of the woody material, and as mentioned, is the binder in the growing plant. In normal paper-making processes the lignin is removed, and in cases where the lignin is not completely removed, as in the cheaper grades of paper, the binding power is not appreciably utilized. This results in what might be termed the "paper-type bond," distinguished from the "wood-type bond" in which the lignins are activated and the bonding power utilized, resulting in a product having high strength, either dry or wet.

Manufacture of lignin plastic

The process is based on releasing the lignin bond in the woody material by the action of high-pressure steam without removing or destroying the lignins and, in fact, so activating the lignins that their bonding power may again be utilized in the manufacture of board products. The high-temperature steam treatment leads essentially to an acid hydrolysis, the acids consisting of acetic and formic acids, developed from the woody material itself under the temperatures employed.

Wood chips are charged into guns each having a capacity of about twelve cubic feet and are treated with steam at pressures up to 1200 lbs. per sq. in. for a matter of seconds. Normally, the entire cycle, including filling and emptying of the guns, will be about one minute. In this time the lignins are first softened by the high temperature steam and then upon sudden release of the chips to

dependable and uniform



P.A.C. FORMALDEHYDE

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Water White, Full Strength, U. S. P.
Low in Acid
Low Metal Content



PARAFORMALDEHYDE

95% Minimum Strength
Powdered or Granular



Adequate Stocks in principal cities assure you prompt deliveries in modern containers

HEXAMETHYLENETETRAMINE

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- **Hexa Granular (Technical)**

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District Sales Offices: Baltimore, Boston, Charlotte, Chicago, Cleveland, Kansas City, Newark, New York, Philadelphia, Pittsburgh, San Francisco

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AMERICAN-BRITISH CHEMICAL SUPPLIES, Inc.
180 MADISON AVE., NEW YORK, N.Y.

A Parade of PROGRESS



THE FIRST MOLDED Durez camera housing made its bow just a few years ago. Today, many of the most popular makes of cameras have housings of this handsome, sturdy material.

SURELY you have noticed the increasing use of Durez plastics for many widely different types of products in recent years. Where once it was primarily used in the electrical, automotive and packaging fields, Durez now is used in products as varied as radios and bilge pumps, cameras and coffee makers. The field of its usefulness is expanding every day!

Today, the possibilities of product development and improvement with Durez plastics are greater than ever. Design limitations have practically vanished. Molding machinery is better. You have a wider choice of Durez molding compounds than ever—and new ones to meet special conditions are being developed constantly.

If you are not fully familiar with the versatility of Durez plastics, it will pay you to look into these modern materials. Like hundreds of other progressive manufacturers you will find that Durez offers design, production and *sales* advantages available in no other material. For detailed information or technical help just write—

DUREZ PLASTICS & CHEMICALS, INC.

10 WALCK ROAD **NORTH TONAWANDA, N. Y.**



UPPER BOWLS for vacuum coffee makers are now molded of a special Durez compound which is unaffected by boiling water and imparts no foreign flavor.



BILGE PUMP HOUSINGS had always been made of metal, until it was found that plastics could do the job better because they defy electrolytic action. But of many plastics tried by the manufacturer only one—Durez 75—could do the job *perfectly!*



PORTABLE RADIOS are now being made with molded Durez housings. That's because of the tremendous popular demand for table radios, millions of which now have these light, attractive, durable housings.

that's a guide to PROFIT!



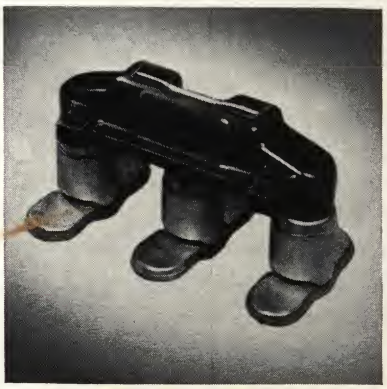
IF IT'S HEAT RESISTANCE you're looking for, you'll be glad to know that Durez has developed special asbestos filled materials that will withstand 490 to 500 degrees F.



OTHER DUREZ special compounds, such as Durez 1543 and 1544, are among the strongest plastics that deliver a high gloss finish.



HIGH IMPACT PLASTICS were always difficult to pre-form until Durez came along with 1900—a material that pre-forms easily, and molds with smooth finish.



DUREZ HAS DEVELOPED many compounds with special properties to meet extraordinary conditions, such as molding around large inserts without shrinking and cracking.



WHERE SHORT DRAW with thin wall sections are required—choose Durez 1762. Created for this type of molding it combines great strength with light weight.



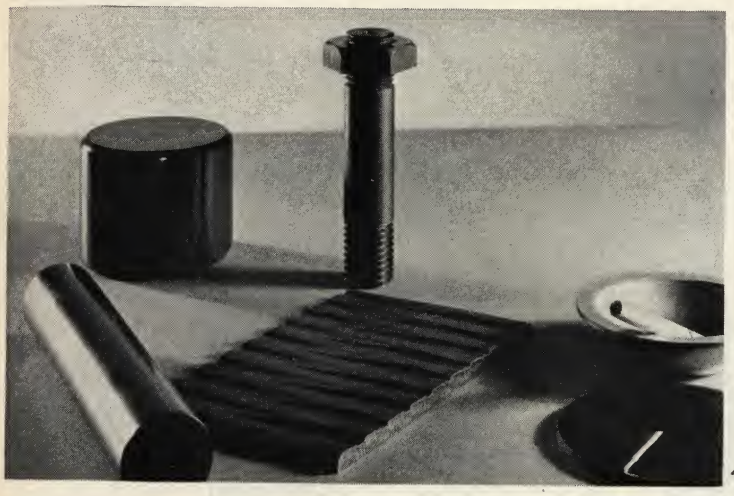
MOLDED PARTS that must be machined or sanded require a molding compound that withstands abrasion. Durez 114SB is one of the best materials of this kind you can get to meet this condition.

DUREZ PLASTICS & CHEMICALS, INC.

PLASTICS THAT FIT THE JOB



3



4

3—Raw material source of lignin stages in process, uncured (Benaloid) and cured (Benalite) moldings. 4—Lignin plastic may be molded into sheets or rods, and then fabricated to final required shape. It is also possible to mold to final specified contours

atmospheric pressure, they are exploded by the high internal pressure, resulting in a mass of fibers and fiber bundles, all still containing their natural coating of lignin. The hemi-celluloses are largely hydrolyzed and removed, the cellulose is partially hydrated but otherwise substantially unchanged, and the lignin has been reactivated so that under suitable conditions it is available to again furnish the wood-type bond which obtained in the growing tree.

In the manufacture of the normal products, this fiber is formed into mats and pressed under pressures ranging from about 50 lbs. per sq. in. to about 300 lbs. per sq. in., depending upon the density desired and at temperatures of about 180 deg. C. until all possible moisture has been removed and the fibers are again bonded by the coating of lignin.

In the study of this pressing method, it was found that the lignin under these conditions actually undergoes a type of plasticity in some ways unlike that experienced with thermosetting resins. For example, after the fibers have been properly bonded under these conditions, the lignin has apparently become set to such an extent that the fibers cannot be disintegrated and rebonded under the same conditions.

Similarity of this action to that of the thermosetting resins naturally led to further study of this phenomenon. It was found that the various fractions of the exploded fiber exhibited somewhat different plasticities and one fraction was isolated which exhibited a very high degree of plasticity and which, when molded, produced a product similar in many ways to phenolic laminated material. Some drawbacks were found from the standpoint of both physical properties and resistance to various chemical agents, but with this as a lead, intensive research finally resulted in producing a type of heat treatment under very carefully controlled conditions of temperature and moisture content of the chips and with careful regulation of the degree of hydrolysis. This resulted in the entire mass being reduced to a plastic state, the products of which, when cured, exhibited the properties desired in a laminated plastic sheet.

Production is accomplished on a large press having twelve openings and pressing panels which trim four feet by twelve feet. Pressures up to 2500 lbs. per sq. in. are available with temperatures up to 280 deg. C. The press is equipped for heating and chilling rapidly and uniformly and is extremely accurate in its construction and in the application of pressure. While the unusually high temperatures and pressures available in the press are not required for the manufacture of the standard cured product, they make possible many modifications and variations.

General characteristics

The product is normally cured at temperatures of about 175 deg. C. and pressures of about 1500 lbs. per sq. in. The only plasticizer required is about four percent of moisture which is normally present at ordinary humidities. Curing is very rapid, in fact it is only required that the temperature of the plastic material be raised to the curing temperature before chilling is started.

The resulting sheet can be surfaced with synthetic resins and colors in the customary way, or for some industrial applications it can be made without any surface material, considerably reducing the cost of the material for applications where surface resin is undesirable or is not required. It is made in all thicknesses from .100 in. to 1.00 in., and although it is suitable for making many shapes, it is normally furnished only in flat panels. It has a specific gravity of 1.45, a modulus of rupture of about 20,000 lbs. per sq. in., a tensile strength of 10,000 lbs. per sq. in., a compressive strength of about 25,000 lbs. per sq. in., a modulus of elasticity of about 2,000,000 lbs. per sq. in. and a 24 hr. water absorption of less than 1 percent. Its dielectric properties are very good, particularly its resistance to surface arcing. It may be drilled, tapped or turned readily, presenting a lustrous black finish.

Forms available

Sheets, rods, tubes and some structural shapes

Trade names

Benalite, Benaloid



LUMARITH

REG. U.S. PAT. OFF.

brings new color and new glamor to a fast growing list of products... When it comes to color, come to Lumarith and ask your molder to show you samples . . . The public likes Lumarith because it is attractive to the eye, smooth to the touch and easy to keep clean and brilliant.



Coil core and coil housing—and—*Completed unit in final assembly*—molded of LUMARITH by Chicago Molded Products Corp. for Sangamo Electric Co. of Springfield, Ill.





LUMARITH-connector blocks molded by Western Electric Co.

LUMARITH

REG. U.S. PAT. OFF.

is like the diamond . . . equally at home in the realm of glamor and in the world of industry. In electrical products, for example, Lumarith offers advantages both in sales appeal and in physical properties (including high dielectric strength). There are production advantages, too . . . easy moldability, low shrinkage in the mold, minimum shrinkage after molding. Lumarith is used by leading custom molders everywhere.







Loop antennae housing made of LUMARITH . . . *LUMARITH-enclosed cockpit.*

LUMARITH-veneered propeller by Engineering & Research Corp.

LUMARITH

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brings a vision of things to come. It anticipates, today, the needs of tomorrow's industries. It has taken wings with aviation. It combines marvelous transparency with high structural and impact strength . . . plus the ability to be formed quickly and easily into complex curves of every kind. And in every application, new and old, Lumarith is backed by Celluloid Corporation, founder of the plastics industry.



LUMARITH

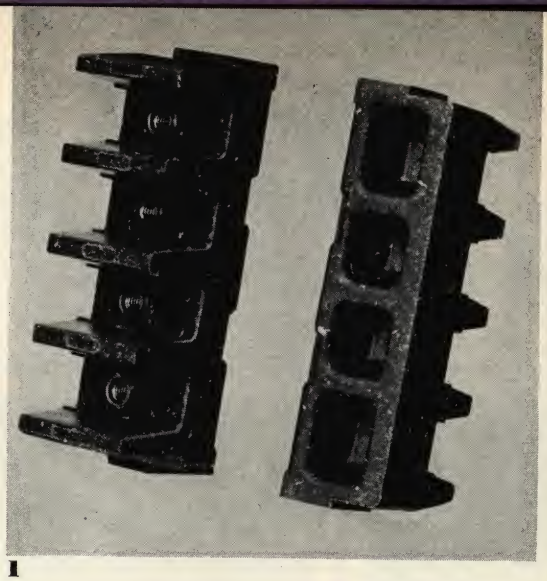
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is available in thousands of colors . . . from the clearest transparents to the deepest opaques and in configurations resembling quartz, onyx, woodgrains, precious and semi-precious stones. When you think of Plastics, think of headquarters . . . the "Grand-daddy of them all" . . . and . . . get in touch with Celluloid.

CELLULOID CORPORATION, 180 Madison Ave., New York City, Sole Producers of Lumarith* (sheets, rods, tubes, rolls, and molding powder), Celluloid* (sheets, rods, tubes and rolls), Lumarith Protectoid* Transparent Packaging Material, H-Scale* Synthetic Pearl Essence, Lindol* Plasticizer, Samson* and Safety Samson* Film Bases. Vimlite*, the Flexible Health Glass Substitute.

**Trademarks Reg. U. S. Pat. Off.*

1—With recent improvements in holding tolerances, asymmetrical electrical shapes as these can now be cold molded. 2—Thermoplax cold molding compounds used for tough, heat-resistant handle for Club Aluminum Co.'s coffee maker designed by Trace and Warner. All molding parts are by Cutler-Hammer Incorporated



1



2

Cold molding compounds

GENERALLY speaking, by cold molding is meant the process of molding powders under pressure in a die at room temperature. However, cold molding can also very well include such compositions as are used for battery boxes, which are kept plastic at a rather high temperature and later formed in a cold die. More specifically, however, and the subject of the present discussion, it is that process whereby the powders are formed into a coherent mass under pressure in a die at room temperature and subsequently heated in ovens to harden. In other words, this procedure is similar to that employed in the manufacture of clay and porcelain except that the final temperature employed in processing is not as high as that used in ceramics.

Unlike hot molders, the cold molders all manufacture their own particular molding powders. This policy has heretofore been considered inevitable due to alleged instability of the powder. However, it is now possible to distribute and market stable cold molding powders in the same manner that hot molding powders are sold today. This revolutionary development coupled with the natural advantages of greater formula modification as well as more rapid production throws open a virgin field to a scientifically inclined manufacturer interested in the production and sale of standardized cold molding powders to molders throughout the country (who are at present already equipped with the necessary presses). As the curing operation is not performed in the die itself, the daily cold molding production rate is much higher than that obtained in hot molding. In addition, the employment of automatic presses and presses actuated by air or cam movements would further increase the production rate. Cold molding also possesses an economical advantage over hot molding when a short production run requiring a single cavity is specified.

Composition and formulation

Cold molding powders are composed of a filler and binder. The filler usually consists of short asbestos fibers together with other minerals, such as clay, talc, slate-flour, barytes, and the like. It is also possible to employ an organic filler such as woodflour. The binders, the characteristics of which very largely determine the properties of the finished product, may be divided into these three main groups.

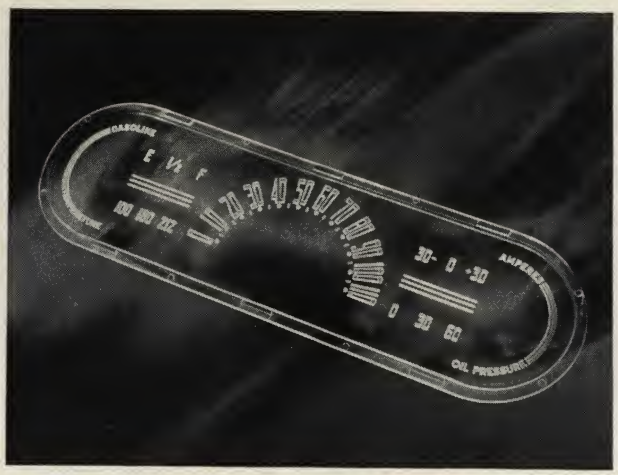
(a) Bituminous
(b) Synthetic resins
(c) Inorganic (Portland cement, sand-lime, etc.)

These three types correspond to the German classification of Types 4; 2 and 3; and X, respectively.

(a) *Bituminous binder.*—This consists of a varnish-like material formulated from various percentages of oils (linseed, tung, castor, oiticica, fish, etc.), natural and synthetic resins (coumarone, indene, copal, dammar, ester gum, etc.), and asphalts (gilsonite, steam-reduced and blown petroleum), together with stearine pitch or vegetable pitch. A selection of these materials is blended together and cooked somewhat in the fashion employed by the varnish maker. This combination is then cut with a thinner or solvent (or a mixture thereof—such as hi-flash naphtha, coal-tar naphtha, mineral spirits, gasoline and benzol) to obtain a heavy liquid of a definite viscosity, determined by the absorptive properties of the filler. The addition of a plasticizer, such as tricresyl phosphate, butyl stearate, dibutyl stearate and chlorinated diphenyl has been found to be of value in aiding plastification and improving the product's resistance to heat.

The binder, which comprises 25 to 30 percent of the finished powder, is added to short asbestos fibers (rang-

ACCENT



PIPING LIGHT—even around corners—is possible with the clearer-than-glass acrylic plastics. Markings are molded into CRYSTALITE car and radio dials which are lighted from the edge to provide even, glare-free illumination.

The Oldsmobile instrument panel, 14″ x 4″, compression molded by the Bay Mfg. Co., is one of more than thirty applications of CRYSTALITE in 1941 cars.



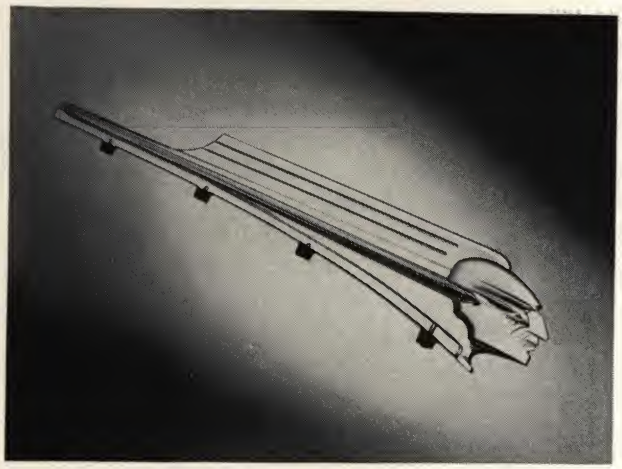
EYE-CATCHING sparkle gives life and beauty to clear CRYSTALITE moldings. Undimmed by time or chemical action, they make practical containers for quality products or ornaments for radios, cars, and lighting fixtures.

Celares cosmetic containers were injection molded by Thomas Mason for Saks Fifth Avenue. Freedom from warpage assures permanent snug fit of top to bottom.



LARGE MOLDINGS are now in regular production—giving daily evidence of CRYSTALITE'S superior molding properties. Guaranteed against shrinkage and warping, strong CRYSTALITE moldings combine utility with clarity.

Hair dryer shield, 26 ounces in weight, 13 inches in diameter, compression molded by General Electric, is the largest thermoplastic molding produced to date.



THICK MOLDINGS show to advantage CRYSTALITE'S colorless transparency. Years of actual outdoor service will prove the permanence of this crystal-clarity even when exposed to sunlight and severe weather conditions.

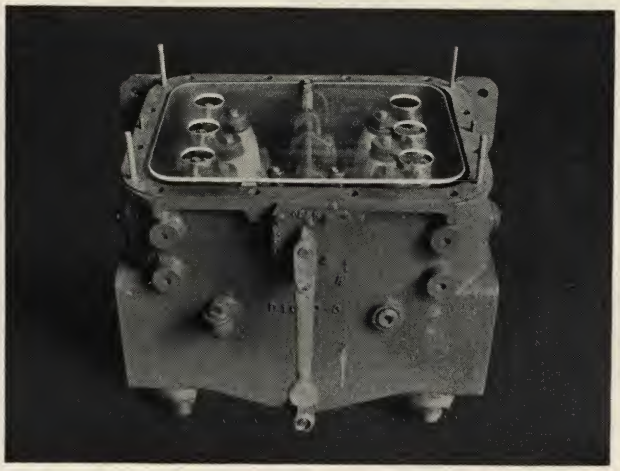
Pontiac's radiator ornament, injection molded by Consolidated Molded Products, weighs six ounces, is more than 14 inches long, and almost ¾ inch thick.

ON CLARITY



SALES APPEAL and utility make PLEXIGLAS ideal for displays, counter units, and signs. Its clarity permits effective presentation of a product's every advantage; its ease of fabrication permits a variety of practical designs.

Two smart young moderns, The Snoody Twins, were created by Frank Maxwell for the display of children's accessories by sawing and forming PLEXIGLAS sheet.



DURABLE, shatterproof PLEXIGLAS is used in industry for inspection windows, machine guards, and gauge glasses. Practically unbreakable, easy to mount, PLEXIGLAS offers high impact strength plus clarity in safety applications.

PLEXIGLAS cover to G & W Electric Company's subway switch permits a visual check of the circuit breakers. Nut-and-bolt mounting is strong and simple.

THE CRYSTAL-CLEAR ACRYLICS

PLEXIGLAS sheets and rods, weatherproof, shatterproof and strong, can be fabricated by bending, sawing, drilling and cementing into crystal-clear ornaments or durable industrial parts.

CRYSTALITE molding powders make possible moldings stronger and lighter than glass, resistant to weathering, moisture and chemical action, and high in dielectric strength.

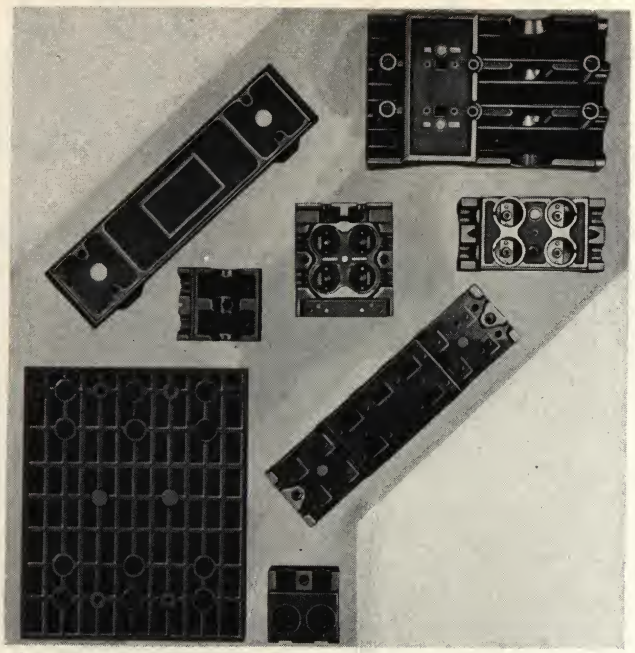
PLEXIGLAS and CRYSTALITE are the trade-marks, Reg. U. S. Pat. Off., for the acrylic resin thermoplastics manufactured by the Röhm & Haas Company.

RÖHM & HAAS COMPANY, INC.

222 West Washington Square, Philadelphia, Pa.



3



4

3—Large structural electrical equipment demands solid, dimensionally stable mounting terminal distributor switch bases and fuse blocks as in these two cold molded panel board parts. 4—A comprehensive aggregation of Hemit parts for cold molded electrical wiring devices. All by Garfield Mfg. Company

ing from Floats to Canadian Classification of 0-0-5-11) together with fibrous talc, clay, red oxide, and vulcanizing or oxidizing agents such as sulphur, selenium, litharge and driers, and various modifying agents, in a kneading machine of the Werner-Pfleiderer type and mixed until a powder having the desired properties is obtained. It is of course essential to quality production that all manufactured powders be uniform in bulk factor, plasticity, particle size, etc. All these control tests should be made before the powder is approved for production utilization. After the material is released from the mixer it is graded and then conditioned by air-drying for a period of about one week so that sufficient solvent will have evaporated. The non-tacky compound thus obtained is now suitable for pressing. (There are several methods of eliminating or modifying this conditioning process so that production may be expedited considerably.) After proper aging, about 0.5 to 1 percent of a lubricant such as a metallic stearate or a neutral soap, is usually added to assist the molding operation. After compression molding in a hydraulic or toggle press, the articles are baked for about 24 hrs. at gradually increasing temperatures (e.g., 4 hrs. at 180 deg. F., 4 hrs. at 250 deg. F., 4 hrs. at 300 deg. F., 4 hrs. at 350 deg. F., etc.), to produce by polymerization, evaporation or oxidation, or a combination of these, a final product of considerable hardness and possessing excellent chemical and dimensional stability upon prolonged exposure to temperatures of about 500 deg. F.

As an example of a typical cold molding powder composition we may cite U. S. Patent 1,671,230 (all parts are estimated on a weight basis):

Binder:	Stearine pitch	40 parts
	Asphalt	60 "
	Castor oil	10 "
	Benzol	25–100 "
Filler:	Asbestos	1100 parts
	Sulphur	66 "
	Iron oxide	22 "

This quantity of filler is used in combination with 286 parts of the binder described. In place of castor oil, linseed, tung or fish oil may be used. Gilsonite, steam-reduced or oxidized asphalt, or mixtures of these, may be substituted in all or in part for the stearine pitch. Driers such as litharge, naphthenates or rosin may be added. Other solvents such as mineral spirits, hi-flash naphtha or gasoline may be used in place of benzol to yield a predetermined viscosity requirement.

(b) *Synthetic resin binder.*—A widely used binder consists of a viscous "A stage" phenolic resin of about 17 to 18 deg. Baumé gravity. A Werner-Pfleiderer or similar mixing machine is usually employed in mixing the binder and the filler (in this instance largely asbestos). The resulting powder is then molded and processed in the regular manner; the baking is generally of shorter duration than with bituminous binder. The powders formulated with synthetic resin binders are rather unstable and must be pressed shortly after being prepared.

(c) *Inorganic binders.*—Cold molding composition made with inorganic binders is known as the "refractory" type. The binders used are Portland cement

Specialized STEARATES

OF
ZINC
CALCIUM
ALUMINUM

● As molding speeds climb steadily higher, it becomes more *essential* to provide better lubrication both for the molding material and for the mold itself. For the complete answer to both these problems, it will pay you to turn to Metasap. For, in addition to giving worry-free lubrication, Metasap Metallic Soaps supply a very desirable plasticizing effect. For further information, write.

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STEARATES
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Harrison, N. J., Boston, Los Angeles, Chicago, Cedartown, Ga.

Ameroid

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Non-inflammable
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THERMOPLASTIC MOLDING POWDER

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OF ESPECIAL INTEREST FOR THE MOLDING OF ELECTRICAL APPLIANCES, INSULATORS, KNOBS, PANELS, SOCKETS, ETC.

Attractive Natural Color, Golden Brown.
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Obtained in Laminated and Filled Forms

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Sole Representatives of Society of Chemical Industry in Basle

MAKALOT PLASTICS ARE USED BY THE COUNTRY'S LEADING MOLDERS

THE NATIONAL LOCK CO. of Rockford, Ill., molders of one of the largest lines of kitchenware, refrigerator handles, etc., are producing this Radio Cabinet, Switchcase Cover and Razor Housing of MAKALOT #1155 The cabinet is sprayed.

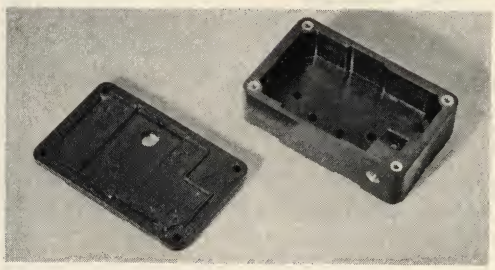








Radio Cabinet



Switchcase and Cover

LOW LOSS MAKALOT

Valpey Crystal Oven—For Police, Aircraft and amateur installations—Valpey Quartz Crystal for direct frequency control, multiple and amateur holders use Makalot Low Loss and Polysterene for their extensive line for radio broadcasting and general communications. F. S. Valpey writing from his factory located at Holliston, Mass., states: "The excellent molding qualities of Makalot compounds not only makes it an excellent material for the manufacture of these units, but has considerably increased our molding production. Your large assortment of molding material and colors enables us to incorporate a powder best suited to the individual application of each unit."

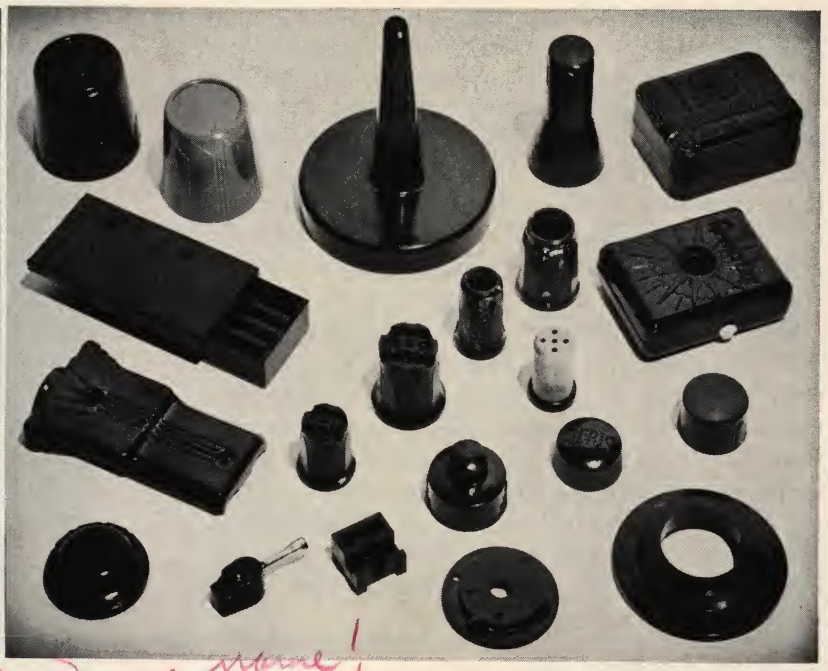


Razor Housing
National Lock Co.



IMPERIAL MOLDED PRODUCTS CORP., Chicago, Ill., use No. 1155 Black MAKALOT in molding the adjustable photographic film developing tank. Stamp Collectors' Rolo-Gage, the unique and useful guide for classifying and evaluating stamps; also stove, percolator, refrigerator handles, name plate frames and various other decorative and useful articles.



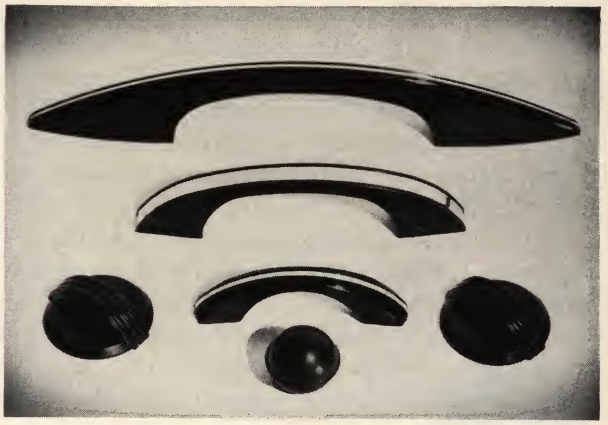


NON-CRACKING MAKALOT

From one of the largest and most modern molding plants in the U. S., The Molded Plastics Division of Reynolds Spring Co., Cambridge, Ohio, comes the above pictured handles and the following letter: "In the attached mailing bag you will find two handles which have been fabricated from seventy-five percent #1962 and twenty-five percent #1904 Black Makalot. This handle is very similar to another handle that we make for another customer and on which we did have an excessive amount of scrap and complaints from customer, due to the cracking material. This cracking was caused by the very large metal insert over which this material is molded. We have found that this mixture of Makalot has practically eliminated all of our trouble, and we are, therefore, glad to pass this information on to you." Rowland L. Hill, Engineering & Standards.

The cracking trouble is shown on one of the large handles referred to by Mr. Hill—note the perfect handles now produced by Makalot

Some of the moldings of TERKELSEN MACHINE CO., Boston, consisting of Old Mr. Boston jigger caps, Obtundobulbs, Kompactlite, Remington type box, Underwriters' Laboratories Approved Heater Plugs, Howard Johnson Salt & Pepper Shakers, Closures, Christmas Husks, etc., of which many millions are molded annually of heat, water, acid resisting non bleeding and general purpose MAKALOT.



Grigoleit Co., Decatur, Ill.

The Independent Producer of Superior Plastics

Makalot CORPORATION

262 WASHINGTON STREET • BOSTON, MASSACHUSETTS

Factory: Waltham, Mass.

MOLDING COMPOUNDS • FABRIC AND PAPER IMPREGNATING RESINS • TUBES, RODS AND SHEETS • PHENOLIC LACQUERS • VARNISHES • ALKYDS

Manufacturers of Molding and Paper Impregnating Resins, Lacquers, Varnishes and Alkyds.

(High Early-Strength being preferred) or lime and silica, together with asbestos, plastic or china clays, and proper amount of water to give sufficient flow and density to the piece when subjected to pressure in the mold. Moldings made with Portland cement binders are usually hardened by soaking in water or in a humidity chamber, whereas those containing sand-lime are processed in steam autoclaves. The finished products normally absorb 10 to 12 percent water. In order to reduce this to a minimum, they are impregnated with materials such as ceresin, amorphous waxes, creosote or pitches such as coal-tar. It is also possible to mix powdered coumarone-indene resin with the asbestos-cement-water mixture before molding. After the molded piece has been cured in water, it is baked in the usual manner in gas or electric ovens. During this operation the resin flows and renders the product impervious to water. In contradistinction to pitches, the articles impregnated with coumarone-indene in this fashion do not track when they are subjected to the electric arc.

Developments during 1940

Advances have been made in the utilization and mechanization of presses for cold molding. In some instances fully automatic presses have been employed, resulting in increased production and reduction in cost. Improvements have been made in appearance and general mechanical properties, especially in those compounds designed for flat-iron connector plugs. Considerable interest has been shown by manufacturers in the possibility of producing cold molding compounds for their own use. This important step should materially assist the growth of the industry as a whole. The application of cold molding principle to the manufacture of ornamental objects such as simulated wood carvings appears to have been given additional impetus.

Very few changes have been made in formulation. The employment of cumarone and alkyd resin together with bitumens furnished a material of higher impact strength and good heat resistance. The introduction of a plasticizing agent, which appears to improve the composition somewhat, has been suggested.

Forms available

At present the only forms available are finished articles produced from cold molding compounds.

Typical applications

Bituminous—find wide employment in the manufacture of handles and knobs for cooking utensils, valve wheels and numerous other articles. One of the chief applications of bituminous cold molding powders is in the manufacture of connector plugs used on flat-irons, toasters, ranges, etc., where high-heat resistance is essential. The recently promulgated requirements of the Board of Fire Underwriters for connector plugs presents a particularly fertile market for the progressive manufacturer of improved cold molding compounds.

Synthetic resin—used for miscellaneous electrical parts. Bituminous cold molded material does find use for electrical purposes but in some instances the water absorption is too high; bituminous material also contains water-soluble matter which is sometimes greatly undesirable. The synthetic resin cold molded type is far superior in this respect although improvement could be made in the bituminous type. Synthetic resins, other than the phenolic, should prove of value as binders for cold molding powders, The synthetic resin type has greater mechanical strength, is considerably tougher than the bituminous type, and can be made with a finish almost equal to that obtained in hot molding.

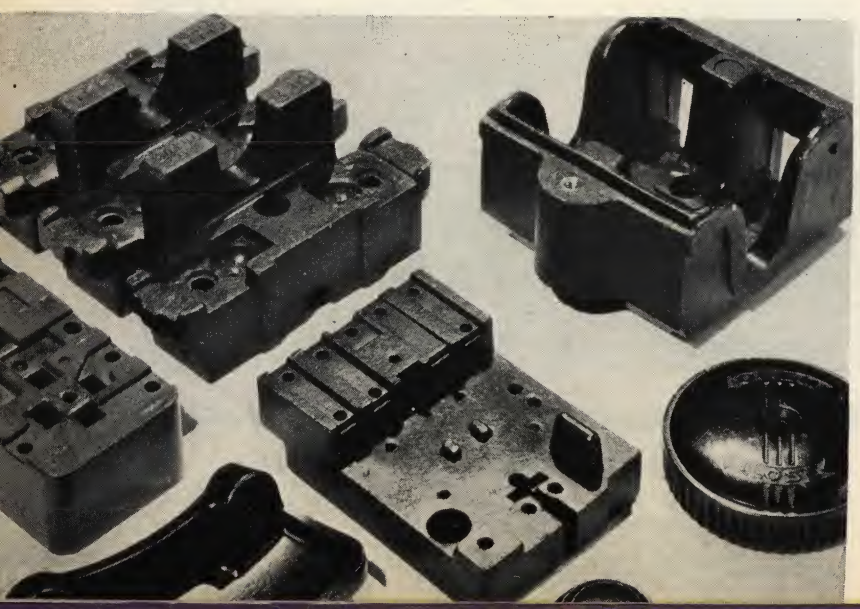
Inorganic.—This type continues to be used where high-heat resistance (up to about 1000 deg. C.) and arc resistance are required. Arc shields, electric heating bases and certain special insulators, etc., demand this type.

Outstanding properties

Heat resistance
Low-cost raw materials
Rapid molding cycle

Trade names

Organic: *Aico, Cetec-Non-Refractory, Ebrok, Gummon, Okon, Thermoplax.*
Inorganic: *Aico-5, Alphide, Cetec-Refractory, Coltstone, Hemit.*



5—Compounds of bituminous, resinous and inorganic raw materials cold molded find their way into many electrical and heat-resistant, strong parts such as these made by American Insulator Company



Hercules

the Choice for SUPERIOR PLASTICS that are

CELLULOSE DERIVATIVES

TOUGH
EASY TO MOLD
CLEAR AS CRYSTAL

Tough

Cellulose plastics are tough, strong, and serviceable. They are beautiful to look at, brilliant with the colors of the rainbow, smooth and warm to the touch. And they are easily, economically formed into useful shapes by the fastest known plastics-molding processes.

PROPERTIES OF CELLULOSE PLASTICS

PROPERTIES	ETHYL CELLULOSE	CELLULOSE ACETATE		CELLULOSE NITRATE (Pyroxylin)
		SHEET	MOLDING	
MOLDING PROPERTIES				
Molding Qualities	Excellent	Excellent	Excellent	Good
Compression Molding Temp., °F	320-360	210-320	250-350	185-250
Compression Molding Pressure, lbs. per sq. inch	1500-2500	500-5000	1500-5000	2000-5000
Injection Molding Temp., °F	380-425	....	300-440	....
Injection Molding Pressure, lbs. per sq. inch	3000-30000	....	8000-30000	....
Compression Ratio	2.2-2.5	....	2-2.8	....
Mold Shrinkage, inches per inch	0.004-0.007	Positive and injection 0.002-0.003; Semipositive 0.005-0.007; Flash 0.008-0.009		....
SPECIFIC PROPERTIES				
Specific Gravity	1.14	1.27-1.37	1.27-1.37	1.35-1.60
Specific Volume, cubic inch per lb.	24.3	21.8-20.2	21.8-20.2	20.5-17.3
Refractive Index, N_D	1.470	1.49-1.50	1.47-1.50	1.50
PHYSICAL PROPERTIES				
Tensile Strength, lbs. per sq. inch	6000-9000	6000-11000	3500-10000	5000-10000
Elongation, %	10-40	20-55	8-30	10-40
Modulus of Elasticity, lbs. per sq. inch x 10^5	2-4	1-3	1-4	2-4
Compressive Strength, lbs. per sq. inch	10000-12000	4000-16000	11000-27000	....
Flexural Strength, lbs. per sq. inch	9000-10000	....	5000-16000	....
Impact Strength, ft. lbs. energy to break ½ x ½ in. bar	0.6-1.8 (Izod)	0.15-0.60 (Charpy)	0.9-1.6 (Charpy)	0.25-1.0 (Charpy)
Hardness (2.5 mm. ball, 10 kg. load), Brinell No.	....	6-11	8-15	8-11
FABRICATION PROPERTIES				
Machining Qualities	Good	Good	Good	Good
Clarity	Transparent translucent opaque	Transparent translucent opaque	Transparent translucent opaque	Transparent translucent opaque
Color Possibilities	Unlimited	Unlimited	Unlimited	Unlimited

Versatile

Hercules cellulose derivatives are pure, free from color and haze, absolutely uniform, and can be "tailor-made" for nearly every user. Thus molders and users find it pays to specify Hercules cellulose derivatives as the base in plastic materials that they buy and use.

MADE FROM HERCULES DERIVATIVES

PROPERTIES	ETHYL CELLULOSE	CELLULOSE ACETATE		CELLULOSE NITRATE (Pyroxylin)
		SHEET	MOLDING	
THERMAL PROPERTIES				
Thermal Conductivity, 10^{-4} cal. per sec. per sq. cm./1° C. per cm.	5.6	5.4-8.7	5.4-8.7	3.1-5.1
Specific Heat, cal. per ° C. per gram	0.25-0.40	0.3-0.4	0.3-0.45	0.34-0.38
Thermal Expansion, 10^{-5} per ° C.	10-14	14-16	14-16	12-16
Resistance to Heat, ° F. (cont.)	140-180	140-180	140-180	ca. 140
Softening Point, ° F.	210-265	140-230	145-260	160-195
Distortion Under Heat, ° F.	130-150	122-212	122-212	....
Tendency to Cold Flow	Slight	Slight	Slight	....
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm.–cms. (50% relative humidity and 25° C.)	10^{15}	(5–30) x 10^{12}	(1–6) x 10^{12}	(2–30) x 10^{10}
Breakdown Voltage, 60 cycles volts per mil (instantaneous)	1500	800-2500	350-900	600-1200
Dielectric Constant, 60 cycles	....	3.5-7.5	4.5-6.2	6.7-7.3
Dielectric Constant, 10^3 cycles	2.5-3.5	3.5-7.0	4.5-6.0	....
Dielectric Constant, 10^6 cycles	2.0-3.0	3.0-5.0	4.0-5.0	6.15
Power Factor, 60 cycles	....	0.02-0.07	0.01-0.04	0.06-0.15
Power Factor, 10^3 cycles	0.005-0.025	....	0.02-0.06	....
Power Factor, 10^6 cycles	0.007-0.03	0.04-0.09	0.04-0.06	0.07-0.10
SERVICE PROPERTIES				
Water Absorption, immersion—24 hrs.	1.25 (48 hrs.)	1.5-3.0	1.4-2.8	1.0-3.0
Burning Rate	Slow	Slow	Slow	Very high
Effect of Age	Slight	Slight	Slight	Slight hardening
Effect of Sunlight	Slight	Slight	Slight	Discolors and becomes brittle
Effect of Weak Acids	Slight	Slight	Slight	Slight
Effect of Strong Acids	Decomposes	Decomposes	Decomposes	Decomposes
Effect of Weak Alkalies	None	Slight	Slight	Slight
Effect of Strong Alkalies	None	Decomposes	Decomposes	Decomposes
Effect of Organic Solvents	Widely soluble	Soluble in ketones and esters; softened or slightly soluble in alcohol; little affected by hydrocarbons		
Effect on Metal Inserts	Inert	Inert	Inert	....



While whole families of new plastics were battling for popular acceptance, two of the well-established cellulose materials accounted for 45.3%* of the dollar-volume in 1939. Of this, 25.6% were cellulose acetate plastics, and 19.7% were nitrocellulose plastics.

Why then, do users and molders so frequently choose cellulose plastics?

The bred-in-the-fiber toughness of those materials, plus their easy workability, exceptional beauty and economy, accounts for their strength against all comers. Then, too, cellulose derivatives can be virtually tailor-made into bases to suit widely varied requirements. This combination of good points is hard to beat.

Hercules does not make molding powders or finished plastics. But after delving into the mysteries of the cellulose molecule for twenty-five years, we have the "know-how" necessary to make top-quality derivatives.

Thus, it pays to specify "Hercules Derivative" on your orders for cellulose plastics and molding powders.

DDD-31

*FIGURES FROM MODERN PLASTICS, MAY, 1940



Familiar to chemists and physicists is the long complex chain-like molecule which gives cellulose plastics their outstanding toughness... combined with lightness and beauty.

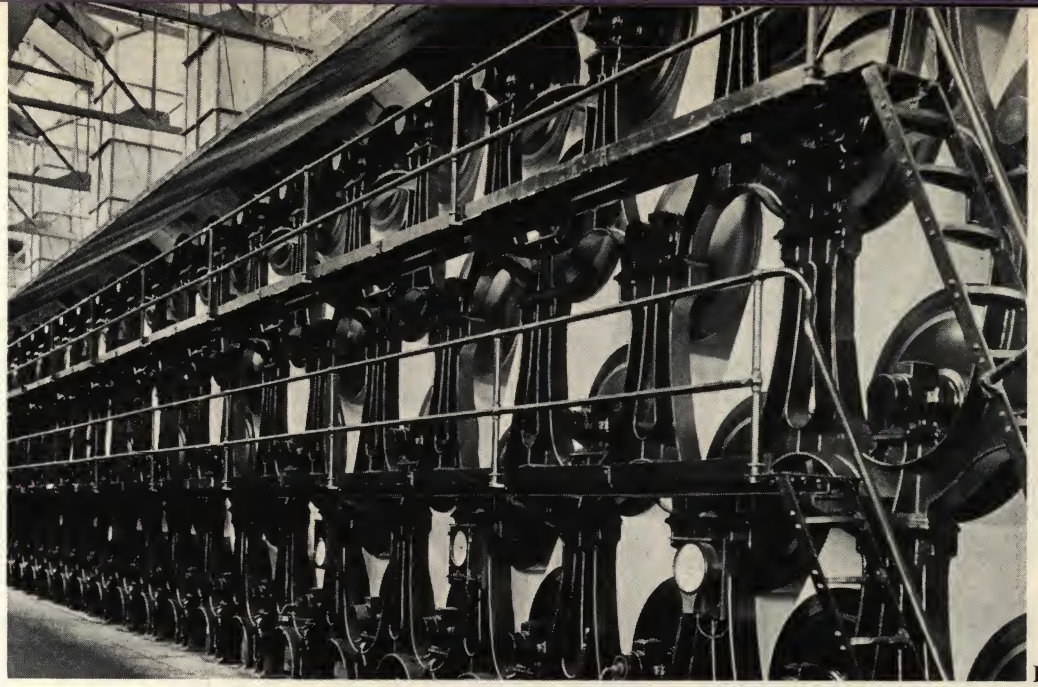
Cellulose Products Department

HERCULES POWDER COMPANY

916 MARKET ST., WILMINGTON, DELAWARE

HERCULES CELLULOSE ACETATE

CELLULOSE DERIVATIVES SOLVE TOUGH PLASTICS PROBLEMS



1—Large drying machine installed at Brown Co.'s plant for drying alpha cellulose fibers. As the sheets come off these rolls they are ready for packaging and shipment

Fillers

PREVIOUS articles in MODERN PLASTICS[1] have dealt with reasons for filler use, the properties imparted to thermosetting resins by fillers, and the particular advantages and disadvantages of various individual fillers. The use of fibrous materials in the preparation of thermosetting plastic molding materials is shown to be unique, in that the filler imparts considerable strength to the molded product. Thus, varied properties are possible in thermosetting materials by virtue of filler selection as well as resin selection. This helps considerably in explaining the well-known versatility of these materials.

Woodflour and cotton flock

In this section we deal with two of the most used fillers, namely, woodflour and cotton. These two fillers are far more widely used than any others in thermosetting resins. Of the two, woodflour is used in much larger volume. The reasons for this have been amply set forth in a previous article.[2] Again, reference should be made to this article for the particular methods necessary to produce the proper fibrous type of woodflour—methods which have evolved over a period of years. Essentially, the wood must be defibered by shearing as contrasted with a strictly cutting operation. In other words, as far as possible the defibering operation must take place in such a manner as to preserve the fibrous structure to the maximum degree. Thus, the maximum strength of this fiber is imparted to the finished molded part.

Cotton being already in a fibrous condition, the problem is one of cutting to the desired mesh and bulk factor. This term *bulk factor* will be explained more fully later, but it should only be noted here that while wood is sheared or ground, cotton is cut to give these filler materials their best properties for molded plastics.

Woodflour and cotton may be obtained in approximately the same mesh. In this finely ground condition, cotton is called *flock*. The presence of foreign materials, such as metallic scrap, is equally objectionable in either filler. Even organic materials, which will not absorb dye, will show up in the finished molded part, causing rejections. Therefore, they must be excluded from the raw material.

Both fillers are available in different shades of color, adaptable to use in producing molded parts of different color. Naturally, the lighter shades command somewhat higher prices. We must of necessity confine ourselves to phenolic compositions, since woodflour-filled products from urea resins have not yet become important commercially in this country.

Considering phenolic materials, Table I indicates why woodflour commands so much greater use than cotton. Most large scale jobs today do not charge molds with powder, but instead, use preforms. This *preforming* is carried out in automatic machines, and to work successfully, it requires a free flowing powder. Cotton-filled molding materials are likely to be deficient in this.

To sum up, it may be seen that, for the molder, the use of cotton-filled molding materials presents problems. Usually, he cannot employ automatic preforming machines and must resort to weighing the charges for each mold cavity or use some other laborious measuring procedure. Either way entails more labor and expense.

(Please turn to next page)

[1] "Why Fillers in Thermosetting Molding Materials?" Modern Plastics, October, 1937, 46. "Filler Requirements," Modern Plastics, October 1938, 30.
[2] Modern Plastics, October 1938, 30.







2—Asbestos mine of the Johns-Manville Co. at Asbestos, Quebec, the source of substantial quantities of filler material used in the United States. 3—Closeup of a piece of Canadian Chrysotile asbestos rock taken from the above mine clearly shows the fibrous structure. 4—Opening and grading asbestos at the Ruberoid Co.—the longer the fibers the more valuable they are. It is packed in sacks classified according to quality

Molds must also be designed with a higher volume content to accommodate the cotton-filled material.

The molded specific gravity difference between cotton and woodflour filler is slight. The difference favors woodflour. The generally accepted specific gravity values are 1.36 for woodflour-filled materials and 1.40 for cotton-filled materials.

In Table I, some of the terms require explanation. By the *apparent density* is meant density of the molding powder in a form ready for charging to the mold. The lower the apparent density of the powder, the deeper must be the mold cavity (if powder is charged to the mold). This is of some importance in cost of dies.

The ratio between the volume of molding material and the volume of the molded piece produced from this same volume of powder is called the *bulk factor*. It may be seen that it is the same as the ratio of molded density to apparent density. Bulk factor and apparent density are, therefore, related. In general, it is desirable to have a high apparent density (which means a low bulk factor). Cotton, as a filler, is at a disadvantage, compared with woodflour, in this respect.

Since the bulk factor of the molding powder is related to some extent to the bulk factor of the filler, the method of cutting or grinding the filler to obtain the best properties in the filler itself is important. This is especially true of cotton, which tends to give high bulk factors.

Up to this point, the comparison has been in favor of woodflour. In subsequent comparisons, the advantages of cotton will be discussed. The tensile, impact and flexural strengths of cotton-filled materials are, on the average, consistently better than woodflour-filled materials. The values, mentioned in Table I, are for the two fillers when cut to approximately the same mesh. Values somewhat higher than those given for cotton can be obtained if longer fiber length is used, but again, the gain will be at the expense of a poorer bulk factor and other related properties.

No doubt some of the superior strength properties of a cotton filler are due to the inherent greater strength of the cotton fiber over the wood fiber. By a parallel lining up of relatively long fibers of cotton, surprisingly high values may be obtained in impact and flexural values in the direction perpendicular to the fibers. This is similar to the grain strength in wood. This may be of some use for such applications as aircraft construction. It is, of course, necessary to know the direction and magnitude of the stresses to take advantage of this special technique.

The properties already given immediately suggest the uses to which molding materials of the two filler types will be placed. Because of their ease of handling, low price and general adaptability to a wide variety of demands, the woodflour-filled materials are used wherever possible. On the other hand, where maximum tensile and flexural strengths are needed along with improved impact strength, the more expensive cotton-filled materials have a distinct advantage. (*Please turn to next page*)

- Let us handle your Cellulose Acetate scrap and other thermoplastic materials
- We do custom grinding (gates, lumps, etc.) assorting magnetizing
- We sell reground molding materials, solid colors, black and mixed colors, light and dark
- We buy scrap, ground or unground, and rejects (will guarantee grinding if desired)

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BROOKLYN, N. Y.
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RAYCO COTTON RAYON CELLOPHANE FLOCK

Cotton:

for filler purposes—uniform cut—grit free—

Rayon:

for decorative purposes — brilliant shades

"Cellophane": (Licensed under pat. #1802547

for decorative purposes—novel effects in filler usage in transparent plastics

Other novelty items for decorative effects
Write for Samples and Information

RAYON PROCESSING CO. of R. I.

Central Falls, R. I.

MAKE YOUR PLASTIC GLOW IN THE DARK

TEK-LITE No. 7—a new luminous dry-powder pigment—just released after 3½ years in research—can be incorporated in the molding of clear or near-clear plastics so that your final product glows in the dark.

ITS QUALITIES:

1. Luminosity very strong.
2. Luminosity lasts hours.
3. Recharges whenever exposed to natural or artificial light.... Does not deteriorate under any known conditions.
4. Entirely harmless—contains no radium or phosphorus.
5. Light weight, easy to process, does not settle out of a hot fluid mixture.
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TEK-LITE NO. 7

Think of all the ways you could use a luminous plastic—write us—we'll help you solve your problems.

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DRUG LEADERS, INC., 610 FOLSOM STREET, SAN FRANCISCO

OHIO-APEX, INC.

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Manufacturers of Plasticizers

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(Dibutyl "Cellosolve" phthalate)

KRONITEX AA, (Tricresyl Phosphate)

METHOX, (Dimethoxy Ethyl Phthalate)
(Dimethyl "Cellosolve" phthalate)

ETHOX, (Diethoxy Ethyl Phthalate)
(Di "Cellosolve" phthalate)

DIOCTYL PHTHALATE

KAPSOL, (Methoxy Ethyl Oleate)

KP-23, (Butyl "Cellosolve" Stearate)

Sales Representatives: Stoney-Mueller, Inc., Lyndhurst, N. J.; Griffin Chemical Co., 1000 16th Street, San Francisco, Calif.

Samples and data on request

"CELLOSOLVE" is a trade mark

TABLE I

COMPARISON OF PROPERTIES

Properties of interest to molders

Apparent density of powder	— Lower for cotton filled
Bulk factor of powder	— Higher for cotton filled
Preformability of powder	— Poorer for cotton filled
Molded density	— Wood filled 1.36—Cotton filled 1.40
Flow range	— Approximately the same

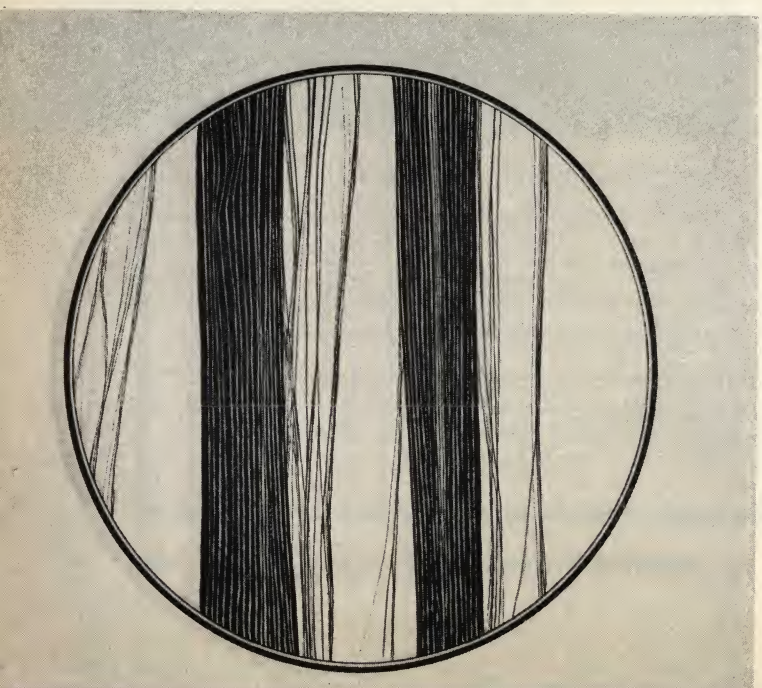
Properties of interest to ultimate consumers

	Wood Filler	*Cotton Filler*
Tensile strength, lbs./sq. inch (molded plastic part)	7000–10,000	8000–12,000
Impact strength, ft. lbs. energy to break (molded plastic part)	0.11–0.20	0.20–0.5
Flexural strength, lbs./sq. inch (molded plastic part)	8500–12,000	10,000–14,000
Electrical properties (molded plastic part)	Equivalent for same resin	

The basic cost of cotton filler is of the order of 4 to 8 times higher than woodflour. This higher raw material cost, plus the greater processing costs, means unavoidably higher price to the ultimate user. However, the increased strength properties very often outweigh these considerations. This has led to an increasing use of cotton. With decreasing costs, as volume goes up, it is confidently believed that the plastics industry will make increasing use of cotton in order to take advantage of its high-strength characteristics.

While the war in Europe has shut off the supply of woodflour from Scandinavia, this has affected consumers of plastics very little, since domestic producers immediately increased production to fill the demand.

5—Under a microscope the hair-like fibers of asbestos are seen to be composed of innumerable still smaller thin fibers. Their oriented arrangement accounts in part for the character of the material. (Photo, courtesy Ruberoid Co.)



5

Asbestos and diatomaceous silica

Two of the more important mineral or inorganic fillers employed in the plastics industry are asbestos and diatomaceous silica. Mineral fillers are required where high heat resistance, exceptional electrical properties or minimum moisture absorption characteristics are required in molded products. In addition, there are other characteristics of each of these fillers that make their use important in the plastics field.

Chemical composition

The term asbestos has now come to include most of the more or less fibrous minerals. However, as employed in the plastics industry, asbestos usually refers to the mineral *chrysotile*. This is a hydrated magnesium silicate, corresponding in composition fairly closely to the formula $H_4Mg_3Si_2O_9$ or $3MgO{\cdot}2SiO_2{\cdot}2H_2O$. Asbestos is employed in the form of fabric, paper and definitely fibrous forms for laminated compositions, etc., but its general use as a filler is as asbestos *fines* or floats, consisting of very fine fibers with associated dust and nonfibrous asbestic material.

Diatomaceous silica is a natural occurring opaline silica, containing three to eight percent of combined water and some two to six percent of other substances in chemical combination (alumina, iron oxide, alkaline earths and alkali metals). The material is of plant origin, consisting of the silicified residues of diatoms, which are microscopic aquatic plants of common occurrence. Diatomaceous silica is unique among mineral fillers because of its microscopic structure, great bulk, high absorptive capacity and low specific gravity.[3]

Chemical analyses for samples of *chrysotile* asbestos from Quebec and Arizona and of a leading grade of commercial diatomaceous silica are given in Table II:

[3] Diatomaceous Silica in Plastics, Modern Plastics, October 1936.

TABLE II

	Chrysotile Canadian	*Chrysotile* Arizona	Diatomaceous Silica
Moisture (Loss at 100° C.)	1.88	0.69	0.30
Combined H_2O (Loss on ignition)	13.60	13.86	0.22
SiO_2	39.91	42.69	92.42
Al_2O_3	1.35	0.39	3.86
Fe_2O_3	2.05	0.63	1.35
MgO	41.57	41.73	0.60
CaO	Trace	0.20	0.28
Na_2O	....	....	1.01
TOTAL	100.36	100.19	100.04

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$CH_2=C(CH_3)-COOCH_3$

Boiling Point.....100.5° C
Specific Gravity.....0.950
Refractive Index.....1.417
Viscosity at 25° C.....0.59
Color.....Water Clear

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6



7



8

6,7—Photomicrographs picture the elongated structure of Dicalite diatomaceous earth fillers from the company's California and Oregon deposits. 8—The detail of the arrangement of the physical structure of this microscopic section shows the innumerable shapes and sizes of the composition in a fraction of Celite diatomaceous filler

General characteristics

Asbestos. The only natural fibrous material of mineral composition available. Its use is required when a fine fibrous filler must be used for temperature conditions above that which can be tolerated by the usual organic fillers, such as woodflour, cellulose, etc., which char at temperatures below that at which any apparent change occurs with asbestos.

The specific gravity of pure *chrysotile* may be as low as 2.25, but for commercial grades the range will be ordinarily from 2.45 to 2.80. Color varies from nearly white to gray. Heat resistance is good to above 1400 deg. F. Dry density of commercial grades varies from 12 to 40 lb. per cu. ft. Fineness specifications vary widely. Fiber length in all materials used as a powdered filler is below $^1/_8$ inch.

Diatomaceous Silica. Its true specific gravity is within the range of 2.0 to 2.3. Apparent density (dry) is 8.0 to 25.0 lb. per cu. ft. Fineness specifications range between four percent retained on 325 mesh, zero percent on 200 mesh to ten to fifteen percent on 150 mesh depending on the use. While diatomaceous silica has an extraordinarily high absorptive capacity for liquids, etc., it is readily mixed with plastic compositions and can be handled satisfactorily in molding operations.

Developments during 1940

The most important development for 1940 in the use of asbestos as a filler in plastics has been an increased use of asbestos fiber for cold molding of many different types. Some asbestos producers have extended technical services to the plastics industry to a considerable extent and definite progress has been made in the further standardization of grades for plastics uses.

For diatomaceous silica the following are perhaps the outstanding new developments:

- Increased uses in the field of phonograph records
- Greater use of diatomaceous silica in high tension electrical parts (x-ray equipment, etc.)
- Adaptation for colored phenolics
- Use of diatomaceous silica in larger molded parts
- Adaptation of diatomaceous filled materials for certain specific molded parts for electrical insulations.

Types of products in which employed

Asbestos	*Diatomaceous Silica*
Heater plugs	Battery boxes
High heat-resistant parts, irons, ovens, etc.	Phonograph records
Electrical panels	Heater plugs
Flooring compositions	Sulphur plastics
Laminated products	Electrical parts
Electrical insulations	Closures
Wax compositions	Surgical parts
Roofings	Asphaltic cements and enamels
Friction materials	Rubber products
"Haveg" type compositions	Box toe compositions
Coating compositions	Phone receivers
	Precision molding

Forms available

Asbestos	*Diatomaceous Silica*
Long fiber	Natural powders and calcined powders of different degrees of fineness and chemical purity
Short fiber	
"Floats"	
Fabric	
Yarn	Different density materials available from very light powders to those of 25 lb. per cu. ft. loose weight
Paper	
Low iron-content grades	

Outstanding characteristics as fillers

Asbestos	*Diatomaceous Silica*
High heat resistance	High heat resistance
Chemical inertness	Chemical inertness
Low moisture absorption	Low moisture absorption
Low shrinkage	Low specific gravity
Low coefficient expansion	Exceptional surface finish
Fair electrical properties	Excellent electrical properties
Permits high loadings	
High impact strength (with better quality grades)	Good to exceptional surface hardness
	Good molding flow

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Now, through the Institute of Plastics Research's first survey of the industry, we have the answer to most of the questions asked about plastics. The Survey is published for the benefit of the plastics manufacturers and users, and for the information of those outside the industry who may have something to sell it.

An introductory section by the foermost authority on plastics in the United States, Dr. Gordon M. Kline of the U.S. Bureau of Standards, gives the history of plastic materials. Trade names, properties and uses of each material are explained.

The Survey itself is illustrated throughout with pictorial statistics. Copies may be had free of charge. A note on your letterhead explaining your interest in the Survey and your intended use of it will bring you a copy.

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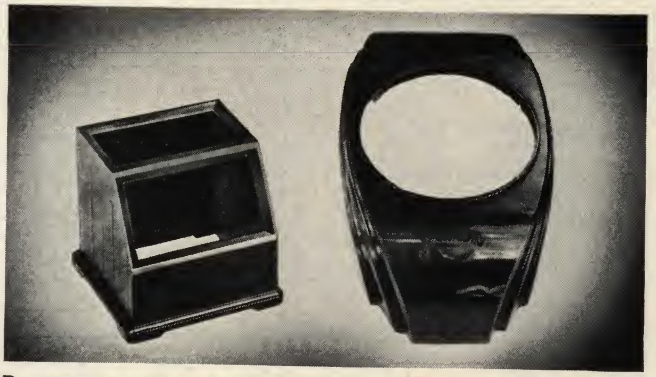
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Coloring materials

WHENEVER a new plastic is developed, and not infrequently when any plastic is modified or adapted to a novel usage, problems arise involving the coloring ingredients. In almost every case a complete line of fashion hues must be obtained and, of course, this involves considerable research work for the colorists.

Properties of coloring matters that have to be studied include the solubility or dispersion characteristics, the stability to and reaction with the chemically reactive plastic (such reactions may be beneficial or detrimental), fastness to heat, light, bleeding, dry cleaning, laundering, crocking, pH changes, ageing, storage, perspiration and to numerous other reagents and to all the products marketed in plastic containers. The density, toxicity, conductivity and degree of transparency are important. Special color characteristics such as dichroism, fluores-

TABLE I. COMPATIBILITY OF COLORING MATERIALS WITH VARIOUS PLASTIC BINDERS

Type of Plastic Binder	Acid Dyes	Mordant Acid Dyes	Basic Dyes	Direct & Developed Dyes	Sulphur Dyes	Vat & Naphthol Dyes	Acetate Dyes	Spirit Soluble Dyes	Oil Soluble Dyes	Insoluble (Organic) Dyes (1), Lakes, Toners	Pigments Inorganic (1)
Acrylate	N(2)	N(2)	C(3)	N	N	C(1)	C(4)	C(1)	C	C(1)	C(1)
Alkyd	N(5)	N(5)	N(5)	N(5)	N	C	N(5)	N(5)	N(5)	N(5)	C(1) (3)
Casein (Soluble Proteins)	C	C	C	C	C	C	N(8)	N	N	C(1)	C(1)
Cellulose:—Acetate	N(2)	N	N(5) (11)	N	N	C(1)	C(6) (4)	C	C	C(3) (1)	C(3) (1)
—Ethers - methyl ethyl-benzyl	N(7)	N	C(3)	N	N	C(1)	C(4)	C	C	C(1)	C(3) (1)
—Nitrate	N(7)	N(7)	C(3)	N(7)	N	C(1)	C(4)	C	C	C(3) (1)	C(3) (1)
Cold Molded: —Organic	N	N	N	N	N	N(7)	C(4)	N	C	C(1)	C(1)
—Inorganic	C	C	C	C	C	C(1)	N(2)	N(7)	N	C(1)	C(1)
Natural: —Water-soluble adhesives	C	C	C	C	C	C	N(8)	N	N	C(7) (1)	C(7) (1)
—Alcohol-soluble shellac, etc.	N(2)	N(2)	C(3) (11)	N(2)	N	C(1)	N(2)	C	N(2)	C(1)	C(1)
—Hydrocarbon-soluble resins	N	N	N(2)	N	N	C(1)	C(4)	N(7)	C	C(1)	C(1)
Phenol-formaldehyde: —Molding powders	N(7)	N(7)	C(3)	N(7)	N	C(1)	C(4)	C(3)	C	C(1) (3)	C(1) (3)
—Laminating varnishes	N(5)	N(5)	N(5) (11)	N(9)	N(9)	N(9)	N(7)	C	N(7)	C(1) (3)	C(1) (3)
—Cast	N(6)	N(6)	N(6)	N(6)	N(2)	N(7)	N(7)	C	C(6)	C(1) (3)	C(1) (3)
Phenol-furfural: —Molding powders	N(7)	N(7)	C(3)	N(7)	N	C(1)	C(4)	C(3)	C	C(1) (3)	C(1) (3)
—Laminating varnishes	N(5)	N(5)	N(5) (11)	N(9)	N(9)	N(9)	N(7)	C	N(7)	C(1) (3)	C(1) (3)
Rubber: —Chlorinated	N	N	N(2)	N	N	C(1)	C(4)	N	C	C(1)	C(1)
—Hydrochloride	N	N	N(2)	N	N	C(1)	C(4)	N(7)	C	C(1)	C(1)
—Hard	N	N	N(2) (11)	N	N	N(7)	C(5) (4)	N	C(5)	C(1) (5)	C(1) (3)
—Tire	N	N	N	N	N(10)	N(10)	C(5) (4)	N	C(5)	C(1) (5)	C(1) (3)
—Sponge	N(2)	N(2)	N(2)	N(2)	N	C(1)	C(2) (4)	N	C(2)	C(1) (5)	C(1) (3)
—Foam	N(2)	N(2)	N(2)	N(2)	C	C(1)	C(2) (8)	N	C(2)	C(1) (3)	C(1) (3)
—Latex	N(2) (7)	N(2) (7)	N	N(2) (7)	C	C(1)	C(2) (8)	N	C(2)	C(1) (3)	C(1) (3)
Styrene: —	N	N	N(2)	N	N	C(1) (3)	C(4) (6)	N(7)	C(6)	C(1)	C(1)
Urea-formaldehyde: —Molding powders	N(6)	N(6)	N(6)	N(6)	N	C(1)	C(6)	C	C(6)	C(3) (1)	C(1)
—Laminating syrups	C(6)	C(6)	C(6)	C(6)	C(2) (9)	C(1) (9)	C(8)	N(2)	N	C(1) (3)	C(1)
Vinyl resins: —Filled	N(2)	N(2)	C(5) (6)	N	N	C(1)	C(5) (4)	N(7)	C(5)	C(1) (3)	C(1)
—Unfilled	N(2)	N(2)	C(5) (6)	N	N	C(1)	C(5) (4)	N(7)	C(5)	C(1) (3)	C(1)
Waxes: —Mineral	N(2)	N(2)	N(2) (7)	N	N	C(1)	C(4) (3)	N	C(3)	C(1)	C(1)
—Vegetable	N(2)	N(2)	N(2) (11)	N	N	C(1)	C(4) (3)	N	C(3)	C(1)	C(1)
Affinity of the dyes	Direct for proteins	Direct for proteins & mordants	Protein, clays & tannin-cellulose	Cellulosic materials, paper, cotton, jute, woodflour, rayon and grasses			Cellulose acetate fabrics	Color materials by absorption, dispersion or mechanical adhesion			

KEY—N = Not compatible, C = Compatible.

Notes on suitability or method:
(1) Not truly soluble, but can be incorporated by dispersion, so rated as compatible by the trade.
(2) Some can be incorporated, but they are not generally suitable.
(3) Some are not suitable, may not be stable or may affect stability of binder.
(4) Refers to the unblended dyes, not to the water-dispersible grades.
(5) A few are suitable, but most are unstable.
(6) Some are stable, but most are not fast enough to light.
(7) Some are suitable for special applications.
(8) Water-dispersible grades can be incorporated, but may not be stable or fast to tests (dry cleaning).
(9) Some are used on pre-dyed or printed fillers.
(10) Purified grades are used on the tire fabrics.
(11) Some of their lye bases or other derivatives are compatible.

cence in daylight or under short wave radiations, phototropism and fading effects are often involved. The economic factors of tinctorial value, cost, uniformity and ready and continuous availability are usually of decisive weight. Often new dyes and new engineering methods must be developed for best results. Naturally, such investigations require specially trained colorists and other technicians. Accordingly, they are preferably cooperative studies of the manufacturers of the plastic and the dyes.

A comprehensive review of the coloring of plastics has already been given by the authors,[1,2] while other writers have discussed some special plastics[3] and inorganic colors.[4] The textile and paper trades have voluminous literature on the coloring of fillers. In this article many data have been condensed into these tables.

The chemical nature and degree of reactivity of coloring matters vary greatly. About 1400 of them have been classified in several standard reference books,[5,6,7] in most cases with reference to their chromophoric nuclei. The marketable mixtures of these compounds, however, are too numerous and too complex to permit practical grouping chemically. Moreover, there has been found no reliable correlation between the chemical constitution of a coloring matter and its suitability and stability in the various types of plastics. Accordingly, colorists generally classify them by their application properties and affinities, hue characteristics, solubility dispersion and fastness properties as summarized in Tables I and II for ready reference.

There are important differences between dyes, lakes (heavy metal salts of dyes, often on inorganic substrata), and the inorganic pigments. All soluble dyes, and some of their lakes, are transparent, whereas most pigments are opaque or dimly translucent. Dyes have excellent tinctorial value when dissolved or very finely dispersed. They are usually bright, strong and give gloss effects. Lakes and pigments generally are softer toned, tinctorially weaker, produce less gloss, increase density and absorb vehicle; but are often faster to light and bleeding. Molding powders can be colored with soluble or insoluble dyes, lakes or pigments; but to varying advantage. An excellent guide with dyes is to select those soluble in a solvent for the plastic concerned. Water soluble binders can be colored either with soluble or water dispersible, insoluble coloring matters. Thread and sheet form plastics constitute groups requiring special dyes and special methods. Binders in emulsion form are best colored before emulsification, preferably with colors insoluble in water.

The major new coloring studies have been concerned with sheet and thread form plastics, such as the transparent wrappers, capsules and films and synthetic textiles differing as widely as Vinyon and Nylon. Fluorescent effects have become popular both for daylight and ultraviolet exposures. The application of plastic syrups, emulsions and coatings not only in laminated work but to textiles, paper, leather, leather cloth and in polishes has increased tremendously. Fortunately, the domestic dye trade has made us independent of foreign color sources. The wars and our national defense programs and both Fairs have, however, affected color trends, specifications and introduced special problems.

1. The Coloring of Plastics, W. H. Peacock, R. H. Kienle, Modern Plastics, October 1936.
2. Coloring Materials, Modern Plastics, October 1939.
3. The Use of Pigments, Lakes and Other Coloring Materials in Plastics, J. H. Clewell & H. W. Payne, Ind. Eng. Chem., **29**, 750 (1937).
4. Colours and Pigments for Plastics, Chemistry and Industry, Jour. Soc. of Chemical Ind., London, **55**, 23, June 1936.
5. Colour Index, Soc. Dyers & Colorists, Bradford, Eng., 1924 and 1928 Suppl.
6. Dyes and Coloring Matters, H. E. Fierz-David, A. W. Joyce, Allen's Commercial Organic Analysis, Vol. VI, 5th Edition.
7. Farbstofftabellen, G. Schultz, Leipzig, 1931.
8. Year Book of the Amer. Assoc. Textile Chemists and Colorists.

TABLE II. GENERAL PROPERTIES OF COLORING MATERIALS USED IN PLASTICS

Type	Affinity	Hue	Solubility Water	Solubility Alcohols	Solubility Hydrocarbons	Dispersibility in Resins	Fastness Properties Heat	Fastness Properties Aldehydes	Fastness Properties Light	Fastness Properties Alcohol & Water	Uses
Acid Dyes	Direct for proteins	Bright and strong	Good	Sparingly	Insol.	Generally poor, varies with dye and conditions	Mod. Mod.	Varies	Good	Bleed	Protein plastics, cast phenolic, urea resins and water-sol. binders
Mordant Dyes	Direct for proteins	Somewhat dull	Good	Spar.	Insol.	Generally poor		Varies	Very good	Bleed	Same as acid dyes
Basic Dyes	Proteins, certain clays, high Tannin Cellulosic materials	Very bright and strong	Good	Good	Insol.	React with many resins Good	Mod. some reds are good	Varies	Poor	Bleed	Can be applied to most plastics. Not used much in hydrocarbon products
Direct & Developed Dyes	Cellulosic materials	Somewhat dull	Good	Spar.	Insol.	Generally poor	Mod.	Varies	Mod.	Bleed	Used to color cellulosic fillers and water soluble binders
Sulphur Dyes	Cellulosic materials	Dull	Sol. in Na_2S solutions	Insol.	Insol.	Poor	Mod.	Good	Good	Good	Used chiefly for rubber tire fabrics and trubenized cloth
Vat Dyes	Cellulosic materials	Somewhat dull & weak	Sol. in alkaline reducing solutions	Insol.	Insol. (Bleed)	Moderate	Mod.	Varies	Very good	Good	Useful in many plastics but they are expensive
Acetate Dyes	Cellulosic acetates	Bright	Insol.	Spar.	Varies	Moderate	Good	Varies	Mod.	Bleed	Cellulose acetate fabrics and sheets
Colors and Lakes	All materials by adhesion	Bright	Insol.	Insol.	Insol.	Good	Good to mod.	Varies	Mod. to good	Many bleed	Resins and cellulose esters
Pigments	All materials by adhesion	Soft toned, dull	Insol.	Insol.	Insol.	Good	Good	Good	Very good	Good	All opaque plastics
Spirit-Soluble Colors	All materials by absorption or adhesion	Bright & strong	Many are sol.	Sol.	Spar.	Good	Varies	Varies	Varies	Bleed	Most plastics that tolerate alcohols in processing
Oil-Soluble Colors	All materials by absorption or adhesion	Bright & strong	Insol.	Spar.	Good	Good	Good	Good	Mod.	Bleed	Resins and cellulose esters and hydrocarbon plastics

Synthetic rubbers*

SYNTHETIC rubber has been the dream of many during the century which has passed since Faraday first determined the carbon-hydrogen ratio in natural rubber, but it has completed only about a decade of commercial success. Each year of the past ten has seen an increase in the number of varieties, the quantity produced, and the number of applications.

In most instances synthetic materials developed to replace those of vegetable or animal origin have been chemically and physically the same as the natural product. However, this has not been true in the case of synthetic rubber. It seems now to be recognized that the desirable physical properties of rubber are not necessarily closely related to its chemical constitution, and since, in almost all its uses, its physical properties are of first importance, the effort to duplicate the chemical constitution of natural rubber has been abandoned.

* Abstracted from Circular C427 of the National Bureau of Standards by Lawrence A. Wood. References to the original sources of the data cited are given in the circular which is available from the Superintendent of Documents, Washington, D. C., for 10 cents.

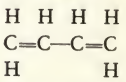
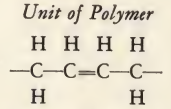
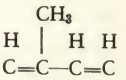
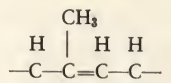
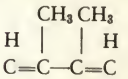
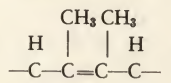
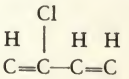
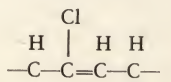
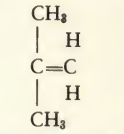
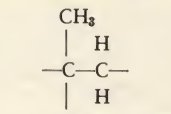
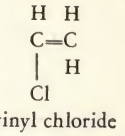
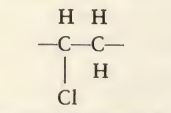
TABLE 1. VARIETIES OF SYNTHETIC RUBBERS

Name	Type	Remarks	Manufacturer	Country of Origin
Ameripol[a]	Butadiene co-polymer		B. F. Goodrich Co.	United States
Buna 85	Butadiene polymer	Molecular weight about 85,000	I. G. Farbenindustrie	Germany
Buna 115	Butadiene polymer	Molecular weight about 115,000	I. G. Farbenindustrie	Germany
Buna N[b]	Butadiene co-polymer	Co-polymer with acrylo-nitrile; now called Perbunan	I. G. Farbenindustrie	Germany
Buna S	Butadiene co-polymer	Co-polymer with styrene	I. G. Farbenindustrie	Germany
Buna SS	Butadiene co-polymer	Co-polymer with styrene—higher styrene content than Buna S	I. G. Farbenindustrie	Germany
Butyl rubber[a]	Olefin-diolefin co-polymer	Molecular weight about 40,000 to 80,000	Standard Oil Co.	United States
Chemigum[a]			Goodyear Tire and Rubber Co.	United States
DuPrene[b]	Chloroprene polymer	Now called neoprene	E. I. du Pont de Nemours & Co., Inc.	United States
Ethanite	Organic polysulphide	Similar to "Thiokol" A	Belgian Cracking Co.	Belgium
Flamenol	Plasticized vinyl chloride polymer		General Electric Co.	United States
Ker	Butadiene polymer		Stomil Co.	Poland
Korogel	Plasticized vinyl chloride polymer	Highly plasticized Koroseal	B. F. Goodrich Co.	United States
Koroseal	Plasticized vinyl chloride polymer		B. F. Goodrich Co.	United States
Levulkan[b]	Butadiene co-polymer	Now called Buna SS	I. G. Farbenindustrie	Germany
Methyl rubber B[c]	Dimethyl butadiene polymer	Sodium used as catalyst	Bayer & Co.	Germany
Methyl rubber H[c]	Dimethyl butadiene polymer	Cold polymerization	Bayer & Co.	Germany
Methyl rubber W[c]	Dimethyl butadiene polymer	Hot polymerization	Bayer & Co.	Germany
Mustone	Chloroprene polymer		Umeno Institute	Japan
Neoprene	Chloroprene polymer		E. I. du Pont de Nemours & Co., Inc.	United States
Oppanol	Isobutene polymer		I. G. Farbenindustrie	Germany
Perbunan	Butadiene co-polymer	Co-polymer with acrylo-nitrile	I. G. Farbenindustrie	Germany
Perbunan Extra	Butadiene co-polymer	Co-polymer with acrylo-nitrile—higher nitrile content than Perbunan	I. G. Farbenindustrie	Germany
Perduren	Organic polysulphide		I. G. Farbenindustrie	Germany
Resinit[b]	Organic polysulphide			Russia
Resistoflex PVA[a]	Polyvinyl alcohol		Resistoflex Corp.	United States
SKA	Butadiene polymer	From petroleum		Russia
SKB	Butadiene polymer	From alcohol		Russia
Sovprene	Chloroprene polymer			Russia
"Thiokol"	Organic polysulphide		Thiokol Corp.	United States
Thionite	Organic polysulphide		Furukawa Electric Co.	Japan
"Vinylite" Series V	Plasticized vinyl chloride co-polymer	Co-polymer with vinyl acetate	Carbide & Carbon Chemicals Corp.	United States
Vistanex	Isobutene polymer		Standard Oil Co. of N. J.	United States
Vulcaplas	Organic polysulphide		Imperial Chemical Industries, Ltd.	England

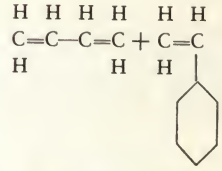
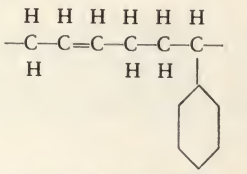
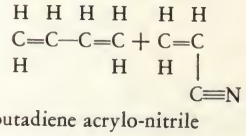
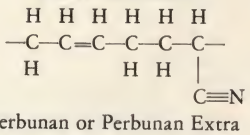
[a] Ed. note: These names added to author's original list.
[b] This term is now commercially obsolete.
[c] These synthetic rubbers were manufactured commercially only during 1915–1918.

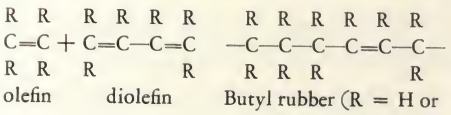
TABLE 2. CHEMICAL STRUCTURES OF DIFFERENT VARIETIES OF SYNTHETIC RUBBERS

Simple Polymers

Monomer	*Unit of Polymer*
	
1,3-butadiene	Buna 85, Buna 115, SKA, SKB, or Ker
	
isoprene (2-methyl-1,3-butadiene)	natural rubber
	
2,3-dimethyl-1,3-butadiene	methyl rubber
	
chloroprene (2-chloro-1,3-butadiene)	neoprene, Sovprene, or Mustone
	
isobutene (2-methyl-1-propene)	Vistanex, Oppanol
	
vinyl chloride	plasticized materials: Koroseal, Korogel, or Flamenol

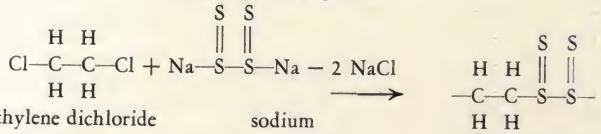
Co-Polymers

	
butadiene styrene	Buna S or Buna SS
	
butadiene acrylo-nitrile	Perbunan or Perbunan Extra



olefin diolefin Butyl rubber (R = H or alkyl group)

Organic Polysulphides



ethylene dichloride (1,2-dichloroethane) sodium tetrasulphide "Thiokol" A

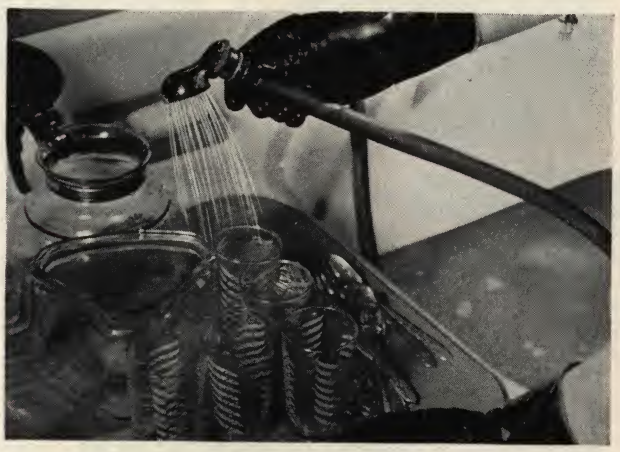
Notes: The bonds between carbon and hydrogen are not indicated. The structural formulas are not intended to give any indications regarding stereo-isomerism. Fuller has recently suggested a ring structure in the organic polysulphides.

The cheapest commercial synthetic rubber today costs about twice as much as the natural product. Nevertheless in recent years certain countries, notably Germany and Russia, insisting upon economic self-sufficiency have considered a high price paid within the country to be of little importance as compared with expenditures in foreign currency for natural rubber. Self-sufficiency in wartime has also been a factor of paramount interest to these governments. These economic and political factors have influenced the scientific objectives and development in the different countries. In a free world market, only a superior synthetic rubber can justify a higher price. Whether or not in the future other countries including the United States will be moved by considerations of self-sufficiency to follow Germany and Russia remains to be seen.

The term "synthetic rubber" in this paper will be taken to mean merely a synthetic substance which has physical properties resembling those of natural rubber; that is, it can be stretched a considerable amount, let us say to an elongation of at least 300 percent and, when released, will quickly and forcibly retract to substantially its original dimensions. About 30 varieties of synthetic rubber are listed in Table 1 under the trade names used by the manufacturers. Of these, some are practically identical, and some are very closely related to others. The chemical constitution of almost all of the varieties listed in Table 1, together with that of natural rubber, is shown in Table 2. *(Please turn to next page)*

1—Household gloves made from Neoprene withstand the rigors of strenuous household dishwashing duties. 2—In drilling oil wells equipment failures must be reduced to a minimum. This rig is equipped with chloroprene synthetic rubber hose. (Photos, courtesy E. I. du Pont de Nemours & Co., Inc.

1



2



Densities

Values of the densities of a number of different varieties of synthetic rubber are shown in Table 3. The temperature of the observation was seldom specified, but may be presumed to have been between 20 and 25 deg. C.

TABLE 3. DENSITIES OF UNVULCANIZED MATERIALS

Material	Density G./Cc.
Natural rubber	0.911
μ-Polymer of chloroprene	1.23
Neoprene	1.25
Perbunan	0.96
Perbunan Extra	0.97
Methyl rubber (20° C.)	0.9292
"Thiokol" A	1.60
"Thiokol" D	1.34
"Thiokol" DX	1.39
"Thiokol" F	1.38
Perduren G	1.68
Perduren H	1.56
Perduren L	1.17
Vistanex HM (25° C.)	0.9125
Vinyl chloride polymer, 0% plasticizer	1.42
Vinyl chloride polymer, 30% plasticizer	1.33
Vinyl chloride polymer, 60% plasticizer	1.25

Tensile strengths

The maximum reported values of the tensile strengths with the corresponding elongations for different kinds of synthetic rubber are given in Table 4. Since the data were necessarily obtained from a number of sources, the conditions of measurement may not have been strictly comparable in all cases. In some instances the figures have been rounded off from those actually observed. The figures refer, respectively, to the unvulcanized material, to a vulcanized compound containing no fillers, and to a vulcanized compound containing approximately the optimum amount of carbon black for maximum tensile strength in each case.

Swelling in liquids

The higher cost of synthetic rubbers is offset in a number of cases by the superiority of some of their properties in comparison with those of natural rubber. Foremost among these properties at present is resistance to the effects of certain liquids, particularly petroleum products. Table 5 presents the results of swelling measurements for natural and synthetic rubbers in a number of liquids in which the swelling of natural rubber is particularly large. The figures have, in some cases, been rounded off from those actually observed. Since the data were necessarily obtained from a number of sources, the values, like those for tensile strength, may not be strictly comparable in all cases. However the figures suffice to give an idea of the orders of magnitude involved and of the relative swelling of different types of synthetic rubber.

TABLE 5. SWELLING OF VULCANIZED COMPOUNDS IN LIQUIDS

Volume Increase, in %, after Immersion for Eight Weeks at Room Temperature

	Natural Rubber	Neoprene	Perbunan	Perbunan Extra	"Thiokol" A	"Thiokol" D	"Thiokol" DX and F
Light gasoline (benzine)	160	...	20	20	0	...	..
Gasoline	230	8	40	...	0	3	3
Kerosene	...	60	...	...	0	2	2
Diesel oil	120	...	15	15	...	...	..
Fuel oil	...	...	...	...	0	10	10
Lubricating oil	...	40	−4	...	0	1	1
Paraffin oil	140	...	3	...	...	...	..
Transformer oil	150	...	5	...	...	...	..
Acetone	...	25	110	110	...	...	9
Benzene	370	160	210	140	7	150	90
Carbon tetrachloride	670	160	220	120	0	40	30
Ethyl ether	130	50	50	...	...	...	..
Linseed oil	100	...	20	...	...	1	1
Turpentine	300	90	50	30	0	...	..

TABLE 4. MAXIMUM TENSILE STRENGTHS AND CORRESPONDING ELONGATIONS

	Unvulcanized		Vulcanized Pure-Gum Compound		Vulcanized Carbon-Black Compound	
	Tensile Strength kg./cm.²	Elongation %	Tensile Strength kg./cm.²	Elongation %	Tensile Strength kg./cm.²	Elongation %
Natural rubber	25	1200	290	710	350	650
Neoprene	30	1100	300	820	290	760
Buna 85	...	...	...	...	175	600
Buna 115	...	...	...	...	200	700
Buna S	...	...	...	...	280	650
Perbunan	...	...	150	900	320	600
Methyl rubber W	...	...	30	510	170	530
Methyl rubber H	...	...	90	240	160	300
"Thiokol" A	...	...	...	...	60	370
"Thiokol" D	7	570	35	750	120	610
Vistanex MM (Oppanol B100)	20	1000	Not vulcanizable		Not vulcanizable	
Vistanex HM (Oppanol B200)	60	1000	Not vulcanizable		Not vulcanizable	
Koroseal 0% plasticizer	400	2	Not vulcanizable		Not vulcanizable	
Koroseal 30% plasticizer	270	170	Not vulcanizable		Not vulcanizable	
Koroseal 60% plasticizer	70	500	Not vulcanizable		Not vulcanizable	
"Vinylite" V 33% plasticizer	210	300	Not vulcanizable		Not vulcanizable	

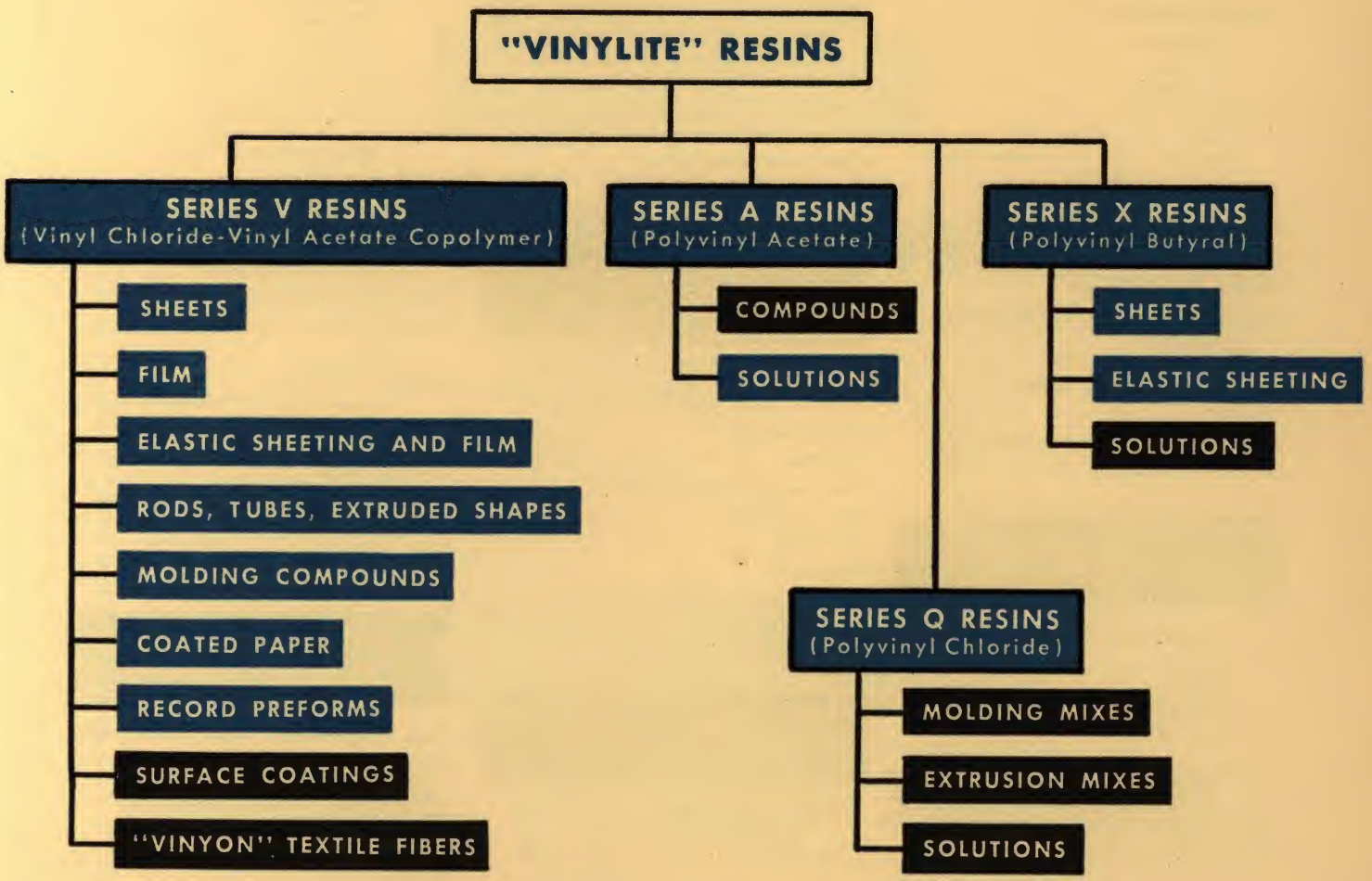
Vinylite Resins

TRADE MARK

available forms . . uses . . properties

All "Vinylite" resins are available in their basic form as white thermoplastic powders. Certain fabricated forms and solutions are also available from Carbide and Carbon Chemicals Corporation. In the following chart, all forms printed on blue are available directly from Carbide and Carbon Chemicals Corporation, and the forms printed on black are available from other formulators, molders, fabricators, or laminators whose names will be furnished to those interested.

The applications enumerated for each of the various forms are suggestive rather than complete, and indicate in a general way the almost limitless possibilities of "Vinylite" resin plastic products. Further information on any of these applications or others which they may suggest will be gladly sent on request.



For uses of these versatile plastics . . see inside

■ Available from Carbide and Carbon Chemicals Corporation.

■ Available from other sources.

SERIES V RESINS

(Vinyl Chloride-Vinyl Acetate Copolymer)

SHEETS

Calendered, Matte, and polished Finish; Transparent, Translucent, and Opaque; Colorless and Colored.

- Advertising Displays
- Advertising Novelties
- Book Covers
- Calling Cards
- Chrome Plating Barrels
- Closure Liners for:
  - Cosmetics
  - Drugs
  - Foods
- Cockpit Covers
- Dials and Windows for:
  - Clocks
  - Radios
  - Refrigerators
- Dress Shirt Fronts
- Floor Tile (with filler)
- Frost Shields for:
  - Aircraft
  - Motor Cars
- Instruments for.
  - Calculating
  - Drafting
  - Navigation
- Packages for:
  - Candy
  - Nuts
  - Men's Accessories
  - Pipes
  - Powder Puffs
- Plastic Bindings
- Price Tag Holders
- Printers' Pica Gauge
- Radio Escutcheons
- Shatter-Resistant Windows for:
  - Aircraft
  - Instruments
  - Rayon Spinning Frames
- Signs
- Storage Battery Separators
- Watch Crystals

FILM

For Lamination to:

- Fabrics
- Leather
- Lithographs
- Photographic Prints
- Printed Matter
- Pulp Board
- Wood

To Protect and Enhance Appearance of Surface. To Provide a Rapid Heat-Sealing Medium, as for Sealing Emblems and Labels to Cloth.

ELASTIC SHEETING AND FILM

Calendered Finish; Transparent, Translucent, and Opaque; Colorless and Colored.

- Belts
- Book Bindings
- Cosmetic Bags
- Electric Cable Insulation
- Furniture Upholstery
- Garters
- Hand Bags
- Laminations
- Luggage
- Physicians' Head Bands
- Shoe Uppers
- Suspenders
- Wallets
- Watch Case Gaskets
- Waterproof Cases and Covers

RODS, TUBES, EXTRUDED SHAPES

Unplasticized and Plasticized

- Beverage Dispensers
- Beverage and Food Tubing
- Electrical Insulation
- Temple Rolls
- Watch Chains

MOLDING COMPOUNDS

Unplasticized and Plasticized, for Injection and Compression Molding.

- Beer Scrapers
- Combs
- Fountain Pens and Pencils
- Hair Curlers
- Ornaments
- Pipe Bits
- Pump Sprayer for Bottles
- Timing Disks
- Tooth Brush Handles

COATED PAPER

(Calendered)

Closure Liners for:

- Cosmetics, Drugs, Foods

Packages

RECORD PREFORMS

For Molding Records for:

- Radio Transcriptions
- Recorded Lectures
- Talking Books
- Wired Music

SURFACE COATINGS

- Artificial Leather Finishes
- Cement Finishes
- Cork Impregnation
  - Liners
  - Stoppers
- Fur Backing Adhesives
- Garment Label Adhesives
- Inks for Resisting Butter, Cheese
- Metal Finishes
  - Air Conditioning Equipment
  - Beer Can Linings
  - Closure Caps
  - Collapsible Tubes
  - Drum Linings For:
    - Beverages
    - Chemicals
    - Foods
    - Paints
  - Flashlight Battery Ends
  - Metal Coasters
  - Processing Equipment
  - Tank Car Linings For:
    - Mineral Oils
    - Wine
- Paper Finishes
  - Decorative Paper
  - Heat-Sealing Paper
  - Hood Caps for Milk Bottles
  - Paper Drum Linings
- Pulp Hat Impregnation
- Stop-off Lacquers for Electroplating
- Textile Finishes
  - Aprons
  - Garment Bags
  - Raincoats
  - Shower Curtains
  - Umbrellas
- Textile Sizes
- Tin and Aluminum Foil Coating
- Wall Tile Finishes
- Wood Finishes
  - Laboratory Furniture

"VINYON" TEXTILE FIBERS

Both Staple Fiber and Continuous Filament Yarn.

- Anode Bags for Electroplating
- Dental Floss, Felt
- Filter Cloths, Sewing Thread

Uses of "Vinylite" Resin Plastic Products

Available from Carbide and Carbon Chemicals Corporation.

Available from other sources.

SERIES A RESINS
(Polyvinyl Acetate)

COMPOUNDS

Adhesives for bonding:
- Films
  - Cellophane
  - Cellulose Acetate
- Glass
- Leather
- Metals
- Mica
- Paper
- Plastics
- Pulpboard
- Textiles
- Wood

Analine Press Inks (Especially Metallic)
Leather Finishes
Molding (Heavily Filled)
Prime Coat over Black Pitch Paint
Stiffening Agent for Decorative Ribbons
Straw Hat Sizing

SOLUTIONS
("Vinylseal" Adhesive)

Edge-Sealing Cloth to Prevent Fraying
Flexible Mica Sheeting
Glass Bricks
Heat-Sealing Film (Calendered)
Heat-Sealing Paper
Hot Drink Cups
Magnetic Structure Laminations
- Motor Stators and Rotors
- Relays
- Transformer Cores

Paper Milk Bottles
Paper Venetian Blinds
Photoflash Bulb Lining
Plastic Wood
Sealing Cellophane Container Liners and Covers
Sealing Cellulose Acetate Film to Printed Stock

SERIES Q RESINS
(Polyvinyl Chloride)

MOLDING MIXES

EXTRUSION MIXES

Electrical Cable Coatings
Flexible Tubings
Gaskets
Tank Linings

SOLUTIONS

Metal Finishes for Making Metal Surfaces Chemically Resistant
Textile Finishes for Waterproofing Fabrics
- Aprons
- Pipe Wrappings
- Raincoats
- Shower Curtains
- Tobacco Pouches

Stop-off Lacquers for Electroplating

NOTE: All forms printed on blue are available directly from Carbide and Carbon Chemicals Corporation, and the forms printed on black are available from other formulators, molders, fabricators, or laminators.

SERIES X RESINS
(Polyvinyl Butyral)

SHEETS

ELASTIC SHEETING

High-Test Safety Glass Interlayer

SOLUTIONS

Adhesives
Leather Finishes

Uses of "Vinylite" Resin Plastic Products

Properties of "Vinylite" Resins

"Vinylite" resins are thermoplastic and can be formed, drawn, laminated, and bonded under moderate heat and pressure. In their basic form, they are odorless, tasteless, non-toxic, and range from non-flammable to slow-burning. Some of them have exceptional resistance to moisture and most chemicals. They are strong and tough even at lower-than-freezing temperatures. They do not warp and have unusual dimensional stability.

The properties of some of the fabricated forms will, of course, vary with the type and amount of plasticizer or other ingredients added to the base resin. Some forms, for instance, are elastic, resembling rubber.

How "Vinylite" Resins are made

The abundant raw materials — water, salt, air, and natural gas—are transformed by chemical synthesis into vinyl chloride and vinyl acetate. These unsaturated compounds are polymerized either singly or in combination to form polyvinyl chloride (Series Q resins), polyvinyl acetate (Series A resins), or the vinyl chloride-vinyl acetate copolymer (Series V resins). Polyvinyl acetate is transformed by hydrolysis and reaction with butyraldehyde into polyvinyl butyral (Series X resins).

These four basic "Vinylite" resins are mixed with pigments, stabilizers, opacifiers, or plasticizers and then calendered, molded, extruded, or dissolved to form "Vinylite" plastic products for an ever-increasing number and variety of uses. They deserve your careful consideration.

Let us help you—Further information on any of the forms and uses of "Vinylite" resins listed in the preceding chart is available and will gladly be sent on request. If you have an application which seems remote from any of those listed, it nevertheless may warrant investigation. Tell us what you have in mind and let us help you determine whether "Vinylite" resins would be practical and profitable in your case. This service involves no obligation.

Plastics Division
CARBIDE AND CARBON CHEMICALS CORPORATION
Unit of Union Carbide and Carbon Corporation
UCC
30 East 42nd Street **New York, N. Y.**

PRODUCERS OF SYNTHETIC ORGANIC CHEMICALS

Vinylite Resins *plastics for many purposes*

TRADE MARK

The words "Vinylite," "Vinyon," and "Vinylseal" are registered trade-marks of Carbide and Carbon Chemicals Corporation.

See inside for uses of these versatile plastics

The first eight liquids are petroleum products, in the handling of which synthetic rubber has been found particularly useful. Unfortunately the common names used for the liquids are insufficient to describe their chemical compositions, which may vary widely with place of origin and subsequent treatment. Since the swelling is determined largely by the chemical composition of the liquid, such a wide variation of values is obtained that the figures quoted for these products are less significant than those for the others. Neoprene, for example, may swell in different lubricating oils at 100 deg. C. as much as 120 percent or as little as 12 percent. Correlation is found with a figure which represents to some extent the ratio of aliphatic to aromatic constituents in the oil.

Permeability

Synthetic rubber compounds can be made which show a greatly decreased permeability to liquids and gases as compared with natural rubber. Part of the advantage is due to the absence of proteins and other non-hydrocarbon constituents, and part to differences in structure. The diffusion constant for water is defined by Taylor, Herrmann, and Kemp as the number of grams of water-vapor passing through one square centimeter of the material one centimeter thick in one hour under a differential pressure of one millimeter of mercury. The values which they found are as follows:

	G. Hr.$^{-1}$ Cm. Cm.$^{-2}$ (Mm. of Mercury)$^{-1}$
Soft vulcanized rubber	6.66×10^{-8}
Ebonite	1.51×10^{-8}
Neoprene, vulcanized	2.63×10^{-8}
"Thiokol" A	0.22×10^{-8}
Plasticized vinyl chloride polymer	3.85×10^{-8}

Aging properties

The second important general superiority of many synthetic rubber compounds is their resistance to deterioration or aging under conditions which impair the utility of natural rubber. Some of these conditions are exposure to the oxygen of the atmosphere, to ozone from electrical discharges, or to light, especially direct sunlight, or to high temperatures. Flex-cracking can also be considerably reduced or eliminated in many cases.

Abrasive characteristics

Losses from abrasion measured in the laboratory are reported to be about the same for the best compounds of Buna 85 and Buna 115 as for a high-grade tire tread of natural rubber. With Buna S the abrasion is said to be about 25 percent less and with Perbunan about 40 percent less. The figures refer to a material containing no softener or plasticizer. With the addition of the plasticizers which are necessary for working the materials on ordinary rubber machinery, as is done in the manufacture of tires on a plant scale, the advantages in resistance to abrasion are considerably reduced. It is stated that road tests in which 40 test cars traveled about 750,000 miles showed losses from abrasion for tires of Buna S and Perbunan to be about 10 percent less and about 30 percent less, respectively, than for tires of natural rubber. More recently the figure of 25 to 35 percent has been given as the result of a long series of road tests on tires of Buna S. The other varieties of synthetic rubber are either inferior to natural rubber in resistance to abrasion, or only slightly superior.

Buna S is at present the type of synthetic rubber in general use in Germany for tires; while Perbunan is generally reserved for those uses where resistance to the effects of liquids is important. There are several important factors dictating the choice of Buna S rather than Perbunan for tires. It is cheaper to produce, and plasticization with hot air is possible. In adhesive properties Buna S is superior to Perbunan, although still inferior to natural rubber. Natural rubber, because of its greater adhesiveness and smaller energy absorption, is sometimes used for the carcass of a tire in which Buna S is used for the tread. A direct bonding between the

3—This Resistoflex polyvinyl alcohol hose is impervious to gasoline, oils and organic solvents. 4—Ameripol or "Liberty Rubber" is the material used for constructing this automobile tire. Manufactured by B. F. Goodrich Company

3



4

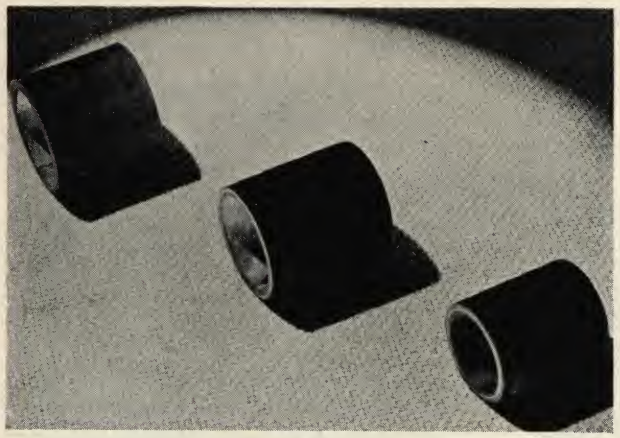




5



6



7

5—Printing rolls made from Thiokol are effective in combating the deleterious effects of modern fast drying inks. 6—This hose of synthetic rubber manufactured by the U. S. Rubber Co. receives rough handling in dispensing gasoline. 7—Thiokol filler neck hoses form the connecting link between the gas tank and the gas line of automobiles. They are molded from an organic polysulphide base material

two, without the use of intermediate material, is possible, but direct bonding is impossible between Perbunan and natural rubber. The lack of sufficient adhesiveness leads to difficulties in building tires with a large number of plies without the use of natural rubber. The manufacture of four-ply and six-ply passenger car tires exclusively from Buna S is said to be on a satisfactory basis, but some problems connected with the manufacture of heavy truck tires apparently have not yet been completely solved.

Each of the properties in which synthetic rubber may be superior to natural rubber, as mentioned in the preceding section, suggests possible applications for the former. Resistance to the effects of liquids, particularly hydrocarbons, is responsible for the very extensive use of synthetic rubber in hose and tubing especially in the handling of petroleum products. In oil fields, refineries, tankers, filling stations, and in the automobile itself, petroleum products now usually pass through hose and tubing of synthetic rubber and into tanks which are sealed with it. Elsewhere in the automobile are many other parts which may come in contact with oil. More of them every year are being made of synthetic rubber or jacketed with it. The number of such parts at present on some cars is said to be as high as thirty or forty. For use in contact with oils, grease, fats, and many chemicals, mountings for vibration absorption, conveyer belts, tires for industrial trucks, gaskets, and sealing devices are being made of synthetic rubber. Additional examples are shoe soles and heels, aprons, gloves, and similar articles for personal use under the same conditions. The relative stability of synthetic rubbers toward certain liquids is responsible for their increasing use in printers' rolls and blankets, engraving plates, and similar articles. Tubes for spraying equipment for paints and lacquers utilize synthetic rubber to advantage. Neoprene, "Thiokol," and Koroseal are widely used in these.

The electrical uses of synthetic rubber deserve special mention. As already noted, Vistanex, Buna S, and the numbered Bunas are the only varieties which show superiorities to natural rubber in respect to purely electrical properties. They are being used as insulation for wires and cables. For many uses, especially at low voltages, the other varieties, such as neoprene, "Thiokol," and Koroseal, may be used also for insulation. There is much wider application, however, of these other varieties as jackets over insulation of natural rubber. They are frequently used in this way to protect natural rubber from the effects of light, air, ozone, oils, and other deteriorating influences. In many types of cables, jackets of synthetic rubber are displacing the lead sheaths formerly used.

The impregnation of silk, cotton, and other fabrics with synthetic rubber of better aging qualities than the natural rubber opens up a large field of household and personal uses. A few examples of products of this type are umbrellas, raincoats, table cloths, shower curtains, and garment bags. Koroseal which can be obtained in an extremely wide variety of colors, is especially applicable in this field.



PLASTICS

The values for the properties in the accompanying chart are based upon maximum and minimun figures submitted by a number of manufacturers o available which excel in one particular property. The manufacturers should always be consulted before making a choice of material. In order

PROPERTIES	PHENOL-FORMALDEHYDE COMPOUNDS								PHENOL-FURFURAL COMPOUNDS			UREA-FORMALDEHYDE COMPOUND	UREA-MELAMINE-FORMALDEHYDE COMPOUND	ANILINE-FORMALDEHYDE RESIN	VINYL CHLORIDE-ACETATE RESINS	
	Molding				Laminated			Cast								
	No Filler	Woodflour Filler	Mineral Filler	Macerated Fabric Filler	Paper Base	Fabric Base	Asbestos Cloth Base	No Filler	Woodflour Filler	Mineral Filler	Fabric Filler	Alpha Cellulose Filler	Alpha Cellulose Filler	No Filler	No Filler	Filled
Molding Qualities	Fair	Excellent	Excellent	Good to fair	—	—	—	—	Excellent	Excellent	Good to fair	Excellent	Excellent	Fair	Good	Excellent
Compression Molding Temp., ° F.	300–340	280–360	270–350	270–330	275–350	275–350	300–350	—	330–400	330–360	300–360	290–325	300–330	300–320	240–275	250–300
Compression Molding Pressure, lbs. per sq. inch	2000–5000	2000–4500	2000–6000	3000–8000	1000–3000	1000–3000	1000–3000	—	1000–3000	1000–3000	1000–3000	1500–6000	1500–6000	1400–5600	1500–2000	2000–2500
Injection Molding Temp., ° F.	—	275-375	275-350	—	—	—	—	—	250-290	250-290	250-290	—	—	—	280–300	—
Injection Molding Pressure, lbs. per sq. inch	—	2000-10000	2000-15000	—	—	—	—	—	300-5000	300-5000	300-50000	—	—	—	15000–22000	—
Compression Ratio	2.0–2.6	2.2–3.0	2.0–7.1	2.5–11.0	1.5-3.0	1.5-3.0	1.6	—	2.5–3.0	2.5–6.0	4.0–15.0	2.5–3.0	2.5–3.0	2.5–3.0	2.0	1.5–3.5
Mold Shrinkage, inches per inch	0.009–0.011	0.006–0.010	0.002–0.006	0.003–0.007	—	—	—	—	0.005–0.009	0.002–0.006	0.0025–0.006	0.006–0.011	0.006–0.011	0.004–0.005	0.001 max.	0.001
Specific Gravity	1.28	1.25–1.52	1.59–2.09	1.37–1.40	1.30–1.36	1.30–1.36	1.55–1.80	1.27–1.32	1.3–1.4	1.6–2.0	1.3–1.4	1.45–1.50	1.49	1.22–1.25	1.34–1.36	1.35–2.5
Specific Volume, cubic inch per lb.	21.7	22.2–18.2	16.4–13.3	20.2–19.8	21.3–20.4	21.3–20.4	17.8–15.0	21.8–20.0	21.3–19.8	17.3–13.9	21.3–19.8	19.1–18.5	18.6	22.7–22.2	20.7–20.4	20.5–11.1
Refractive Index, n_D	—	—	—	—	—	—	—	1.5–1.7	—	—	—	1.54–1.56	1.575–1.60	—	1.53	—
Tensile Strength, lbs. per sq. inch	6000–9000	4000–11000	4000–10000	6500–8000	7000–18000	8000–12000	7000–12000	5000–12000	6000–11000	5000–10000	6500–8000	5500–7000	—	8500–10000	8000–10000	6000–12000
Elongation, percent	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Modulus of Elasticity in Tension, lbs. per sq. inch × 10^5	7–10	10–15	10–45	7–12	4–20	3.5–15	3.5–15	5–15	10–25	10–45	7–12	12–15	12–15	3–4	3.5–4.1	3.5–8.5
Compressive Strength, lbs. per sq. inch	—	16000–36000	18000–36000	20000–32000	20000–40000	30000–44000	18000–45000	15000–30000	28000–36000	24000–36000	26000–30000	24000	—	23000	—	—
Flexural Strength, lbs. per sq. inch	12000–17000	8000–15000	8000–20000	10000–13000	13000–20000	13000–30000	10000–35000	9000–15000	8000–15000	8000–20000	10000–13000	10000–13000	10000–19000	14000–17000	10000–13000	7500–12000
Impact Strength, ft. lbs. per in. of notch $\frac{1}{2} \times \frac{1}{2}$ in. notched bar, Izod test	0.32–0.40	0.20–0.56	0.22–0.72	0.8–4.8	0.6–7.6	1.4–15	1.8–11	0.1–0.4	0.30–0.56	0.32–0.74	1.20–4.60	0.28–0.32	0.28–0.32	0.32	0.6–1.2	0.2–1.4
Hardness, Brinell No. (2.5 mm. ball,25 kg. load)	—	30–45	—	—	24–40	30–45	35–45	30–45	35–40 (50 kg.)	44–46 (50 kg.)	30–35 (50 kg.)	48–54 (500 kg.,10 mm.)	—	—	12–15	15–25
Hardness, Rockwell	M80–M130	M100–M125	M85–M120	M85–M110	M70–M120	M70–M120	M70–M110	M80–M130	B63–B75	B54–B62	B65–B75	M110–M130	—	—	—	—
Thermal Conductivity, 10^{-4} cal. per sec. per sq. cm./1° C. per cm.	—	4–12	8–20	3–5	5–8	5–8	—	3–5	3.5–5	10–20	5–8	7.1	—	4.5	4.0	Varies
Specific Heat, cal. per ° C. per gram	—	0.35–0.36	0.25–0.35	0.30–0.35	0.3–0.4	0.3–0.4	—	0.3–0.4	0.3–0.4	0.3–0.4	0.3–0.4	0.4	—	—	0.24	Varies
Thermal Expansion, 10^{-5} per ° C.	—	3.7–7.5	2.5–4	2–6	1.7–2.5	1.7–3	1.7–2.5	2.8	3	2	4.5	2.5–3.0	—	5	6.9	Varies
Resistance to Heat, ° F. (continuous)	250	350	450	250–350	212–300	212–350	400–450	160	280–400	350–500	280–350	170	210	ca. 180–190	—	—
Softening Point, ° F.	None	None	None	None	None	None	None	—	Chars 450	Chars 550	Chars 400	None	None	ca. 260	140–150	140–158
Distortion under Heat, ° F.	240–260	240–285	—	—	>320	>320	>320	—	268-288	277-297	—	260–280	285	ca. 230	140–150	140–158
Tendency to Cold Flow	—	None	None	None	None	None	None	—	None	None	None	Very low	Very low	None	Slight	Slight
Volume Resistivity, ohm-cms. (50% relative humidity and 25° C)	(1–5) × 10^{12}	10^{10}–10^{12}	10^{8}–10^{11}	10^{8}–10^{11}	10^{10}–10^{13}	10^{10}–10^{13}	—	10^{8}–10^{14}	10^{10}–10^{12}	10^{8}–10^{11}	10^{9}–10^{11}	10^{12}–10^{13}	—	> 10^{12}	> 10^{14}	10^{11}
Dielectric Strength, short-time volts per mil, ⅛ in. thickness	400–500	300–500	250–400	300–450	400–1300	150–600	60–150	300–450	400–600	200–500	200–500	650-720	—	> 600	650	—
Dielectric Strength, step-by-step volts per mil, ⅛ in. thickness	250–350	200–350	200–400	200–350	350–700	150–400	50–125	200–350	—	—	—	300–380	321	—	—	—
Dielectric Constant, 60 cycles	5–6	5–12	5–20	5–10	—	—	—	5–10	—	—	—	7.6–8.6	11.5–11.6	3–4	—	—
Dielectric Constant, 10^3 cycles	4–5	4–8	4.5–20	4.5–6	—	—	—	—	4–8	4.5–20	4.5–6	—	—	3.46	—	4.7
Dielectric Constant, 10^6 cycles	4.5–5	4.5–8	4.5–20	4.5–6	3.6–5.5	4.5–7	—	5-7	6–7.5	5–18	5–7.5	6.6–7.7	—	3.38	4	4
Power Factor, 60 cycles	0.05–0.10	0.04–0.30	0.10–0.30	0.08–0.30	—	—	—	0.025–0.20	—	—	—	0.040–0.055	0.15–0.17	0.01–0.02	—	—
Power Factor, 10^3 cycles	0.025–0.06	0.04–0.15	0.10–0.15	0.08–0.20	—	—	—	0.005–0.08	0.04–0.15	0.1–0.15	0.08–0.20	—	—	0.004	0.014	0.02–0.15
Power Factor, 10^6 cycles	0.015–0.04	0.035–0.1	0.005–0.10	0.04–0.10	0.02–0.05	0.02–0.08	—	0.01–0.045	0.035–0.1	0.04–0.1	0.035–0.1	0.027–0.035	—	0.006	0.018	0.02–0.065
Water Absorption, immersion—24 hrs.	0.1–0.2	0.2–0.6	0.01–0.3	1.0–1.3	0.3–9.0	0.3–9.0	0.3–2.0	0.01–0.5	0.2–0.6	0.01–0.15	0.8–1.4	1–3	0.2–0.6	0.05	0.05–0.15	0.2–4.0
Burning Rate	Very low	Very low	Nil	Approx. nil	Very low	Very low	Approx. nil	Very low	Very low	Nil	Nil	Very low	Very low	Very Low	Nil	Nil
Effect of Age	None	None	None	None	Improves mechanical and electrical properties			Hardens slightly	Hardens slightly	Hardens slightly	Hardens slightly	Hardens slightly	Hardens slightly	None	Strength unaffected	None
Effect of Sunlight	Surface darkens slightly	Light shades discolor			Lowers surface resistance			Colors may fade	Light shades discolor			None	None	Darkens	Darkens	Discolors
Effect of Weak Acids	None to slight depending on acid								None to slight depending on acid			←	None	Decomposes	Resistant	Dependent on filler
Effect of Strong Acids	Decomposed by oxidizing acids; reducing and organic acids no effect								Decomposed by oxidizing acids; reducing and organic acids no effect			Decomposed or surface attacked	Very slight	Decomposes	Resistant	Dependent on filler
Effect of Weak Alkalies	Slight	Slight to marked depending on alkalinity							Slight to marked depending on alkalinity			←	None	None	Resistant	Dependent on filler
Effect of Strong Alkalies	Decomposes	Decomposes	Decomposes	Decomposes	Decomposes	Decomposes	Decomposes	Decomposes	Decomposes	Decomposes	Decomposes	Decomposes	Attacked	Slight	Resistant	Dependent on filler
Effect of Organic Solvents	None	None on bleed-proof materials						None	None on bleed-proof materials			←	←	Attacked by some	Resists alcohols, aliphatic hydrocarbons, and oils. Soluble in ketones and esters; swells in aromatic hydrocarbons	
Effect on Metal Inserts	Inert	Inert	Inert	Inert	Inert	Inert	Inert	Inert	Inert	Inert	Inert	Inert	Inert	Inert	Inert	Inert
Machining Qualities	Fair		Fair to good			Fair to excellent		Excellent	Fair to good			Fair	Fair	Excellent	Good	Good
Clarity	Transparent; translucent	Opaque	Opaque	Opaque	Opaque	Opaque	Opaque	Transparent translucent opaque	Opaque	Opaque	Opaque	Translucent opaque	Translucent opaque	Translucent brown color	Transparent translucent opaque	
Color Possibilities	Dark colors	Limited	Limited	Limited	Limited	Limited	Limited	Unlimited	Limited	Limited	Limited	Unlimited; pastel shades	Unlimited; pastel shades	Limited; dark colors only	Unlimited, pastels to black	

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Note: The Plasticizers chart may be found opposite page 446, and the Solvents chart opposite page 424.

PROPERTIES CHART - 1941

s of each type of plastic material. Differences in test procedures and sizes of test specimens may lead to erroneous conclusions in some cases if direct comparisons are attempted. Special grades of materials are often er to facilitate communication with the producers of these materials, a list giving trade names and addresses for each of these chemical type of plastics has been prepared and will be found in the Directory Section

	VINYL CHLORIDE AND VINYL CHLORIDE-ACETATE RESINS (Plasticized)	VINYLIDENE CHLORIDE RESINS	METHYL METHACRYLATE RESIN		STYRENE RESIN	SHELLAC COMPOUND	COLD MOLDED		RUBBER COMPOUNDS			ORGANIC POLYSULFIDE MOLDING COMPOUND	CASEIN	NYLON RESINS	LIGNIN PLASTIC	CELLULOSE COMPOUNDS		
			Cast	Molding			Non-Refractory (Organic)	Refractory (Inorganic)	Chlorinated Rubber	Modified Isomerized Rubber	Hard Rubber					Ethyl-cellulose	Cellulose Acetate	
																	Sheet	Molding
t	Fair	Good	Good	Excellent	Excellent	Good	Fair	Fair	Fair	Good	Fair	Good	Poor	—	Good	Excellent	Excellent	Excellent
0	220–350	220–350	—	285–370	220–275	240	—	—	310–380	260–300	285–350	240–300	200–225	—	365	320–360	210–320	250–350
0	500–1000	500–3000	—	1000–3000	1000–5000	1000–2500	4000–12000	4000–12000	2000–5000	1200–4000	1200–1800	500–5000	2000–2500	—	1500–2000	1500–2500	500–5000	1500–5000
	—	275–350	—	325–500	300–500	180–260	—	—	310–400	—	180–220	—	—	—	—	380–425	—	300–440
	—	5000–40000	—	10000–30000	10000–30000	1000–1200	—	—	—	—	2000–5000	—	—	—	—	3000–30000	—	8000–30000
.5	—	—	—	1.6–2.2	2.0–2.3	2–3	2.5	3.5	2.2–2.6	3	4–6	2.5–3.0	—	—	—	2.2–2.5	—	2–2.8
	0.016	0.013	—	Compression 0.001–0.005 Injection 0.003–0.006	Compression 0.002–0.005 Injection 0.002–0.008	0.002	0.000–0.017	0.000–0.008	—	0.000	—	0.015–0.020	—	—	—	0.004–0.007	Positive and injection 0.002–0.003; Sem 0.005–0.007; Flash 0.008–0.009	
5	1.2–1.6	1.6–1.75	1.185	1.18–1.19	1.054–1.070	1.1–2.7	1.87–2.15	1.63–1.85	1.64	1.06	1.12–1.80	1.54–1.55	1.35	1.14	1.45	1.14	1.27–1.37	1.27–1.37
.1	23.0–17.3	17.3–15.8	23.4	23.4–23.2	26.3–25.9	25.2–10.3	14.8–12.9	17.0–15.0	16.9	26.1	24.7–15.4	18.0–17.8	20.5	24.3	19.1	24.3	21.8–20.2	21.8–20.2
	—	1.60–1.63	1.49	1.49	1.59	—	—	—	1.56	—	—	—	—	1.55	—	1.470	1.49–1.50	1.47–1.50
00	1000–9000	Up to 60000	7000–9000	4000–6000	5000–9000	900–2000	—	—	2700–5000	4300	4000–10000	1500–1700	7600	10000–50000	9000–10000	6000–9000	5000–11000	3500–10000
	2–500	25	5–15	1–5	2–5	—	—	—	0.5–2.2	—	2–15	150–400	—	30–35	—	10–40	15–55	5–50
	—	0.4–2.4	4–6	—	1.7-2.0	5–6	—	—	1–5	4.7	5.3	—	5.1–5.7	4.5	15–20	1–4	1–3	2.0–3.5
	—	—	11000–13000	10000–15000	11500–13500	10000–17000	6000–15000	16000	—	8500–11000	8000–12000	—	—	—	25000–35000	10000–12000	4000–16000	7000–27000
00	—	15000–17000	14000	10000–15000	14000–19000	—	3700–9300	1400–4700	9000–16000	7000–9000	8000–15000	—	—	14000	15000–20000	4000–12000	4000–8000	3700–16000
4	—	2–8 (unnotched)	0.25–0.5	0.2–0.4	0.35–0.50	2.6–2.9	0.4	0.4	0.14–2.8	2.6	0.5	—	1.0	—	0.7–0.8	0.6–1.8	1.6–4.0	0.7–4.2
	—	—	18–20	18–20	20–30	—	—	—	70–80 (Shore)	85–90 (Shore)	31	72–98 (Shore)	23	—	—	—	6–11 (10 kg.)	6–15 (10 kg.)
	—	—	M70	M70	M87–M90	—	M36–M66	M23–M29	—	—	—	—	—		M100–M112	—	L35–L50	R15–R110
	3.9–4.0	2.2	1–10	—	1.9	—	—	—	3.0	2.6–2.9	3.2	—	—	—	—	5.6	4.5–7.8	4.5–7.8
	0.32–0.51	0.32	0.35	0.35	0.32	—	—	—	0.37	—	0.33	—	—	0.55	—	0.25–0.40	0.3–0.4	0.3–0.4
	—	—	8	8–9	6–8	—	—	—	12–13	7–8	8.0	—	8	—	2.1–2.4	10–14	11–16	11–16
	150	160–200	140–160	120–140	—	150–190	500	1300	—	—	—	150–200	—	—	—	140–180	140–250	140–250
3	—	200–325	150–230	150–230	190–250	150	—	—	175–230	165–220	150–190	—	200	482	—	210–265	140–230	145–260
3	—	150–200	155	125–160	170–180	—	—	—	140	167–221	—	—	—	—	—	130–150	122–212	122–212
	Slight	Slight	Very slight	Slight	Slight	Slight	—	—	Slight	Slight	Slight	Some	—	—	—	Slight	Slight	Slight
	8×10^{13}	6×10^{13}	10^{15}	10^{15}	10^{17}–10^{19}	1.8×10^{9}	1.3×10^{13}	—	2.5×10^{12}	$(5–7) \times 10^{16}$	10^{15}–10^{16}	—	—	10^{13}	—	10^{15}	$(5–30) \times 10^{13}$	$(0.7–1.4) \times 10^{13}$
	600–2000	500–2500	500	500	500-700	200–600	85	—	2300	—	250–900	500	400–700	—	300–400	1500	800–2500	350–900
	350	—	400	400	—	—	50–100	40–85	—	—	—	—	—	—	300–400	—	—	—
	12.0	3–5	3.5	3.0–3.1	2.5–2.6	3–4	15.0	—	3	2.7	2.8	7.5	—	3.2	—	2.7	3.5–7.5	3.5–6.4
	—	3–5	3.2	3.3–3.5	2.5–2.6	4–5	—	—	3	2.68	2.8–3.4	—	—	3.3	—	2.5–3.5	3.5–7.0	3.5–6.4
	—	3–5	3.2	3.1–3.3	2.5–2.6	—	6.0	—	—	—	3	—	6.15–6.8	3.6	—	2.0–3.0	3.0–5.0	3.2–6.2
	13.6	0.03–0.08	0.06	0.05–0.06	0.0001–0.0002	0.004–0.04	0.20	—	0.003	0.006	—	0.55	—	0.010	—	0.007	0.02–0.07	0.01–0.06
5	—	0.03–0.15	0.06	0.06–0.07	0.0001–0.0002	0.05	—	—	—	—	0.003–0.008	—	—	0.015	—	0.005–0.025	—	0.01–0.06
5	—	0.03–0.05	0.025	0.02–0.03	0.0001–0.0004	—	0.07	—	0.006	0.002	0.003–0.008	—	0.052	0.022	—	0.007–0.03	0.04–0.09	0.01–0.05
0	—	0.00	0.4	0.4–0.5	0.00	—	0.6–7.5	0.5–26	0.1–0.3	0.02	0.02	0.04	7–9	7.6 (sat'd)	0.75	0.5–1.5	1.5–3.0	1.0–2.8
	Nil	None	Slow	Slow	Slow	High (wood filler)	Nil	Nil	Nil	Slow	Medium	Slow	Very low	Very low	Slow	Slow	Slow	Slow
	None	None	Practically nil	Practically nil	Very slight	None	—	—	Slight embrittlement	None	None	Slight to none	Hardens slightly	None	None	Slight	Slight	Slight
rs	Slight	Slight	Very slight	Very slight	Yellows slightly	None	—	—	Darkens	Slight surface crazing	Discolors; surface resistivity decreases	Unaffected	Colors may fade	Unaffected	Slight	Slight	Slight	Slight
nt	None	None	Practically nil	Practically nil	None	Deteriorates	Slight	Decomposes	Resistant	Resistant	Resistant	Resistant	Resistant	None	None to slight	Slight	Slight	Slight
nt	None	None	Affected only by oxidizing acids		None	Deteriorates	Decomposes	Decomposes	Resistant	Resistant	Attacked by oxidizing acids	Attacked by oxidizing acids	Decomposes	Attacked by oxidizing acids	Attacked by oxidizing acids	Decomposes	Decomposes	Decomposes
nt er	None	None	Practically nil	Practically nil	None	Deteriorates	None	None	Resistant	Resistant	Resistant	Resistant	Softens	None	Slight to marked	None	Slight	Slight
nt r	None	None	Practically nil	Practically nil	None	Deteriorates	Decomposes	None	Resistant	Resistant	Resistant	Slight	Decomposes	None	Decomposes	None	Decomposes	Decomposes
dro- e in aro-	Soluble in ketones and esters	Highly resistant	Soluble in ketones, esters and aromatic hydrocarbons		Soluble in aromatic and chlorinated hydrocarbons	Attacked by some	Attacked by some	None	Soluble in aromatic hydrocarbons	Softens and swells in some	Attacked by some	Resistant	Resistant	Resistant to common solvents	None to slight	Widely soluble		Soluble in ketones and ened or slightly solubl little affected by hydroc
t	Inert	Inert	Inert	Inert	Inert	Inert	Inert	Inert	—	Inert	—	Inert	—	—	Inert	Inert	Inert	Inert
od	Good	Good	Excellent	Excellent	Fair to good	Poor to Good	Poor	Poor	—	Good	Fair	Fair	Good	—	Fair to good	Good	Good	Good
	Transparent to opaque	Transparent to opaque	Transparent (90–92 % light transmission)		Transparent (88–90% light transmission)	Opaque	Opaque	Opaque	Translucent opaque	Transparent	Opaque	Opaque	Translucent opaque	Translucent, opaque	Opaque	Transparent translucent opaque	Transparent translucent opaque	Transparent translucent opaque
lack	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	Limited; pastels excluded	Dark colors only	Gray	Pastels to black	Unlimited	Limited	Black	Unlimited	Unlimited	Limited	Unlimited	Unlimited	Unlimited

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3T - 1941

izes of test specimens may lead to erroneous conclusions in some cases if direct comparisons are attempted. Special grades of materials are often
list giving trade names and addresses for each of these chemical type of plastics has been prepared and will be found in the Directory Section

LAC M- ND	COLD MOLDED		RUBBER COMPOUNDS			ORGANIC POLYSULFIDE MOLDING COMPOUND	CASEIN	NYLON RESINS	LIGNIN PLASTIC	CELLULOSE COMPOUNDS					PROPERTIES
	Non-Refractory (Organic)	Refractory (Inorganic)	Chlorinated Rubber	Modified Isomerized Rubber	Hard Rubber					Ethyl-cellulose	Cellulose Acetate: Sheet	Cellulose Acetate: Molding	Cellulose Acetate Butyrate	Cellulose Nitrate (Pyroxylin)	
d	Fair	Fair	Fair	Good	Fair	Good	Poor	—	Good	Excellent	Excellent	Excellent	Excellent	Good	Molding Qualities
)	—	—	310–380	260–300	285–350	240–300	200–225	—	365	320–360	210–320	250–350	250–350	185–250	Compression Molding Temp., ° F.
2500	4000–12000	4000–12000	2000–5000	1200–4000	1200–1800	500–5000	2000–2500	—	1500–2000	1500–2500	500–5000	1500–5000	1500–5000	2000–5000	Compression Molding Pressure, lbs. per sq. inch
-260	—	—	310–400	—	180–220	—	—	—	—	380–425	—	300–440	310–410	—	Injection Molding Temp., ° F.
-1200	—	—	—	—	2000-5000	—	—	—	—	3000–30000	—	8000–30000	8000–30000	—	Injection Molding Pressure, lbs. per sq. inch
3	2.5	3.5	2.2–2.6	3	4–6	2.5–3.0	—	—	—	2.2–2.5	—	2–2.8	2.0–2.4	—	Compression Ratio
002	0.000–0.017	0.000–0.008	—	0.000	—	0.015–0.020	—	—	—	0.004–0.007	Positive and injection 0.002–0.003; Semipositive 0.003–0.007; Flash 0.008–0.009			—	Mold Shrinkage, inches per inch
2.7	1.87–2.15	1.63–1.85	1.64	1.06	1.12–1.80	1.54–1.55	1.35	1.14	1.45	1.14	1.27–1.37	1.27–1.37	1.14–1.22	1.35–1.40	Specific Gravity
-10.3	14.8–12.9	17.0–15.0	16.9	26.1	24.7–15.4	18.0–17.8	20.5	24.3	19.1	24.3	21.8–20.2	21.8–20.2	24.3–22.8	20.5–19.8	Specific Volume, cubic inch per lb.
-	—	—	1.56	—	—	—	—	1.55	—	1.470	1.49–1.50	1.47-1.50	1.47–1.48	1.50	Refractive Index, nD
2000	—	—	2700–5000	4300	4000–10000	1500–1700	7600	10000–50000	9000–10000	6000-9000	5000–11000	3500–10000	2500–7500	5000–10000	Tensile Strength, lbs. per sq. inch
—	—	—	0.5–2.2	—	2-15	150–400	—	30–35	—	10–40	15–55	5–50	8–82	10–40	Elongation. percent
5	—	—	1–5	4.7	5.3	—	5.1–5.7	4.5	15–20	1–4	1–3	2.0–3.5	2.0–3.5	2–4	Modulus of Elasticity in Tension, lbs. per sq. inch × 10^5
-17000	6000–15000	16000	—	8500–11000	8000–12000	—	—	—	25000–35000	10000–12000	4000–16000	7000–27000	7500–22300	—	Compressive Strength, lbs. per sq. inch
-	3700–9300	1400–4700	9000–16000	7000-9000	8000–15000	—	—	14000	15000–20000	4000–12000	4000–8000	3700–16000	2800–13000	8000–10000	Flexural Strength, lbs. per sq. inch
2.9	0.4	0.4	0.14–2.8	2.6	0.5	—	1.0	—	0.7–0.8	0.6–1.8	1.6–4.0	0.7–4.2	0.8–5.5	2.0–8.0	Impact Strength, ft. lbs. per in. of Notch $\frac{1}{3} \times \frac{1}{2}$ in. notched bar, Izod test
-	—	—	70–80 (Shore)	85–90 (Shore)	31	72–98 (Shore)	23	—	—	—	6–11 (10 kg.)	6–15 (10 kg.)	6–12	8–11 (10 kg.)	Hardness, Brinell No. (2.5 mm. ball, 2.5 kg. load)
-	M36–M66	M23–M29	—	—	—	—	—		M100–M112	—	L35–L50	R15–R110	—	R60–R100	Hardness, Rockwell
-	—	—	3.0	2.6–2.9	3.2	—	—	—	—	5.6	4.5–7.8	4.5–7.8	4.5–7.8	3.1–5.1	Thermal Conductivity, 10^{-4} cal. per sec. per sq. cm./1° C. per cm.
-	—	—	0.37	—	0.33	—	—	0.55	—	0.25–0.40	0.3–0.4	0.3–0.4	0.3–0.4	0.34–0.38	Specific Heat, cal. per ° C. per gram
-	—	—	12–13	7–8	8.0	—	8	—	2.1–2.4	10–14	11–16	11–16	11–16	12–16	Thermal Expansion, 10^{-5} per ° C.
90	500	1300	—	—	—	150–200	—	—	—	140–180	140–250	140–250	140–250	ca. 140	Resistance to Heat, ° F. (continuous)
-	—	—	175–230	165–220	150–190	—	200	482	—	210–265	140–230	145–260	140–250	160–195	Softening Point, ° F.
-	—	—	140	167–221	—	—	—	—	—	130–150	122–212	122–212	136–200	—	Distortion under Heat, ° F.
ht	—	—	Slight	Slight	Slight	Some	—	—	—	Slight	Slight	Slight	Slight	Slight	Tendency to Cold Flow
10^9	1.3×10^{12}	—	2.5×10^{12}	$(5–7) \times 10^{16}$	10^{12}–10^{15}	—	—	10^{12}	—	10^{15}	$(5–30) \times 10^{12}$	$(0.7–1.4) \times 10^{12}$	$(0.7–1.4) \times 10^{12}$	$(2–30) \times 10^{10}$	Volume Resistivity, ohm-cms. (50% relative humidity and 25° C.)
600	85	—	2300	—	250–900	500	400–700	—	300–400	1500	800–2500	350–900	250–400	600–1200	Dielectric Strength, short-time volts per mil, $\frac{1}{8}$ in. thickness
-	50–100	40–85	—	—	—	—	—	—	300–400	—	—	—	—	—	Dielectric Strength, step-by-step volts per mil, $\frac{1}{8}$ in. thickness
4	15.0	—	3	2.7	2.8	7.5	—	3.2	—	2.7	3.5–7.5	3.5–6.4	3.5–6.4	6.7–7.3	Dielectric Constant, 60 cycles
5	—	—	3	2.68	2.8–3.4	—	—	3.3	—	2.5–3.5	3.5–7.0	3.5–6.4	—	—	Dielectric Constant, 10^3 cycles
-	6.0	—	—	—	3	—	6.15–6.8	3.6	—	2.0–3.0	3.0–5.0	3.2–6.2	3.2–6.2	6.2	Dielectric Constant, 10^6 cycles
.04	0.20	—	0.003	0.006	—	0.55	—	0.010	—	0.007	0.02–0.07	0.01–0.06	0.01–0.06	0.06–0.15	Power Factor, 60 cycles
05	—	—	—	—	0.003–0.008	—	—	0.015	—	0.005–0.025	—	0.01–0.06	0.01–0.06	—	Power Factor, 10^3 cycles
	0.07	—	0.006	0.002	0.003–0.008	—	0.052	0.022	—	0.007–0.03	0.04–0.09	0.01–0.05	0.01–0.05	0.07–0.10	Power Factor, 10^6 cycles
	0.6–7.5	0.5–26	0.1–0.3	0.02	0.02	0.04	7–9	7.6 (sat'd)	0.75	0.5–1.5	1.5–3.0	1.0–2.8	0.8–2.0	0.6–2.0	Water Absorption, immersion—24 hrs.
gh filler)	Nil	Nil	Nil	Slow	Medium	Slow	Very low	Very low	Slow	Slow	Slow	Slow	Slow	Very high	Burning Rate
ne	—	—	Slight embrittlement	None	None	Slight to none	Hardens slightly	None	None	Slight	Slight	Slight	Slight	Slight hardening	Effect of Age
ne	—	—	Darkens	Slight surface crazing	Discolors; surface resistivity decreases	Unaffected	Colors may fade	Unaffected	Slight	Slight	Slight	Slight	Slight	Discolors and becomes brittle	Effect of Sunlight
orates	Slight	Decomposes	Resistant	Resistant	Resistant	Resistant	Resistant	None	None to slight	Slight	Slight	Slight	Slight	Slight	Effect of Weak Acids
orates	Decomposes	Decomposes	Resistant	Resistant	Attacked by oxidizing acids	Attacked by oxidizing acids	Decomposes	Attacked by oxidizing acids	Attacked by oxidizing acids	Decomposes	Decomposes	Decomposes	Decomposes	Decomposes	Effect of Strong Acids
orates	None	None	Resistant	Resistant	Resistant	Resistant	Softens	None	Slight to marked	None	Slight	Slight	Slight	Slight	Effect of Weak Alkalies
orates	Decomposes	None	Resistant	Resistant	Resistant	Slight	Decomposes	None	Decomposes	None	Decomposes	Decomposes	Decomposes	Decomposes	Effect of Strong Alkalies
acked some	Attacked by some	None	Soluble in aromatic hydrocarbons	Softens and swells in some	Attacked by some	Resistant	Resistant	Resistant to common solvents	None to slight	Widely soluble	Soluble in ketones and esters; softened or slightly soluble in alcohol; little affected by hydrocarbons				Effect of Organic Solvents
ert	Inert	Inert	—	Inert	—	Inert	—	—	Inert	Inert	Inert	Inert	Inert	—	Effect on Metal Inserts
oor to Good	Poor	Poor	—	Good	Fair	Fair	Good	—	Fair to good	Good	Good	Good	Good	Good	Machining Qualities
paque	Opaque	Opaque	Translucent opaque	Transparent	Opaque	Opaque	Translucent opaque	Translucent, opaque	Opaque	Transparent translucent opaque	Transparent translucent opaque	Transparent translucent opaque	Transparent translucent opaque	Transparent translucent opaque	Clarity
pastels ded	Dark colors only	Gray	Pastels to black	Unlimited	Limited	Black	Unlimited	Unlimited	Limited	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	Color Possibilities

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MOLDING and FABRICATING

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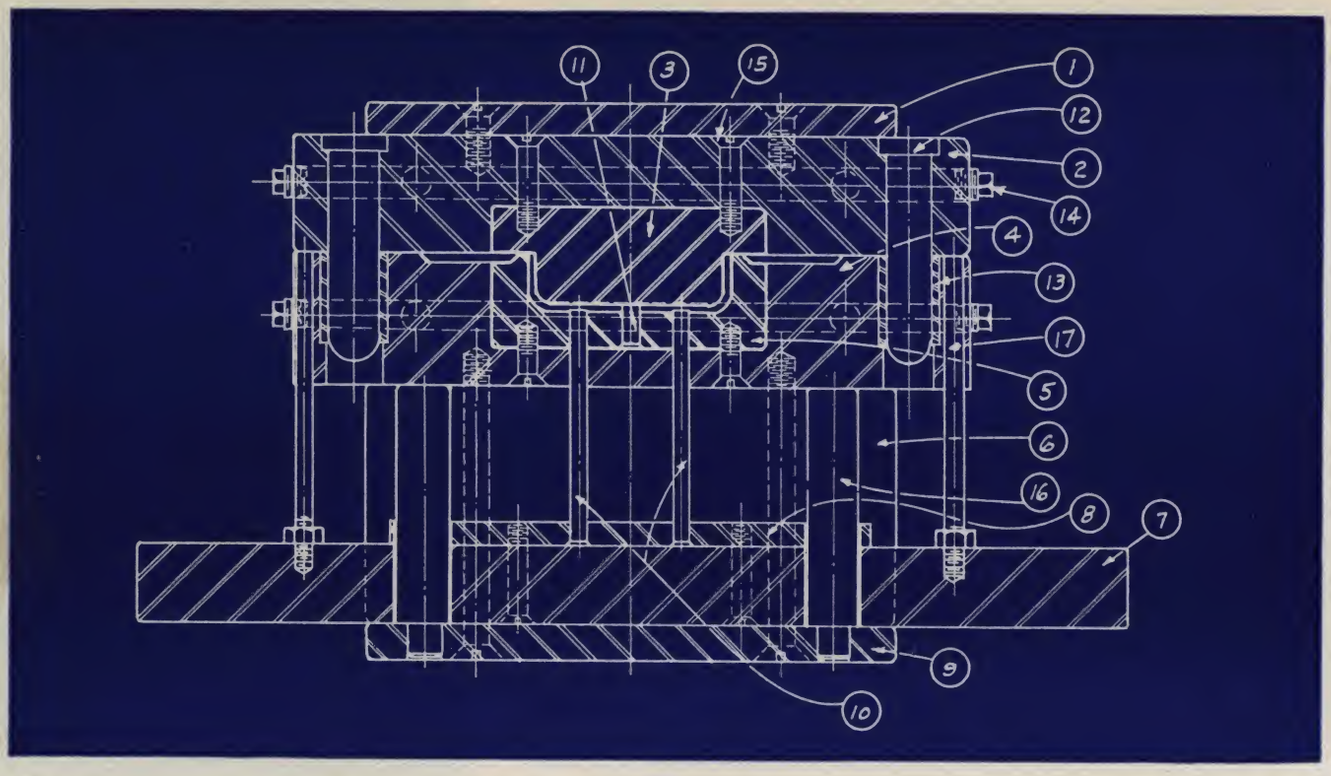


Fig. 1. Flash mold

Design of molds

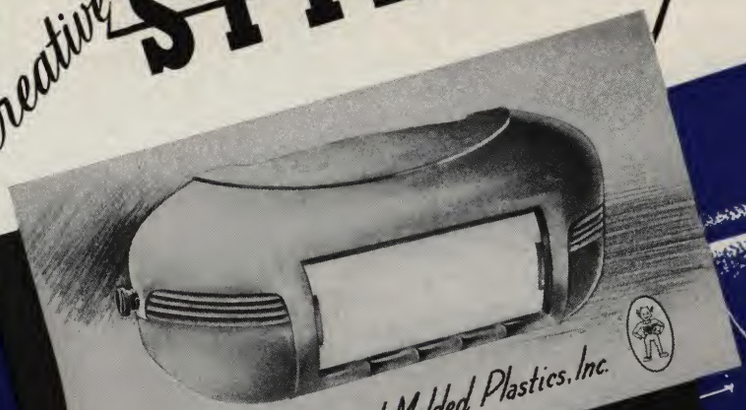
IN the manufacture of plastics it is necessary in most cases to design and build a mold before molded parts can be produced. It is, therefore of the greatest importance when designing a mold, that most careful consideration be given to all the subsequent manufacturing operations by the mold designer. The difference between a carefully designed mold and a poorly designed mold is often the difference between profit and loss to the producer of the molded parts, or it can mean a satisfied or a dissatisfied customer.

Mold designers should be men with a thorough working knowledge of the methods and equipment used in the manufacture of the molds. They should also have a thorough knowledge of the methods and equipment used in pressing, finishing, and in any other operation which it is necessary to perform to produce a molded part satisfactory to the customer. The mold designer must always realize that it is not enough to just design a mold to produce molded parts, but that these parts must be produced of a quality and at a price satisfactory to the customer. Further, the cost of the mold must be low enough to allow the molder a reasonable return on his complete investment.

There are four general types of molds, known as: flash mold (Fig. 1), landed plunger mold (Fig. 2), loading plate mold (Fig. 3), and straight plunger mold (Fig. 4). A fifth type, known as a sub-cavity type mold (Fig. 5), is not commonly used due to excessive waste of material in the molding operation. These various types of molds may be built as hand molds or semi-automatic molds, according to the production requirements, or to fit into the press equipment of the individual molder who is to manufacture the parts. These mold types may also include wedges, pull pins, threaded pins for internal threads, threaded rings for external threads, spring box arrangement for inserts, stripper plates, and interchangeable sections. Following is a brief description of each of the first four mold types mentioned. These are shown diagrammatically in the article.

Flash mold.—A flash mold as shown in Fig. 1 is the simplest type mold to design and build. It consists of a (1) top plate, (2) top retainer steam shoe, (3) plunger, (4) bottom retainer, (5) cavity, (6) parallels, (7) knockout bar, (8) pin retainer plate, (9) bottom plate, (10) knockout pins, (11) mold pins, (12) guide pins, (13) guide pin bushings, (14) pipe plugs, (15) screws, (16) support pins, and (17) safety pins. In designing a flash mold, care should be taken to see that the top and bottom plates are thick enough and are fastened securely to the steam retainer plate and parallels to withstand the pull exerted when the press is opened. This pull is caused by the material flowing under pressure up the side walls of the cavity and around the plunger, and solidifying under the heat and pressure. Guide pins and guide

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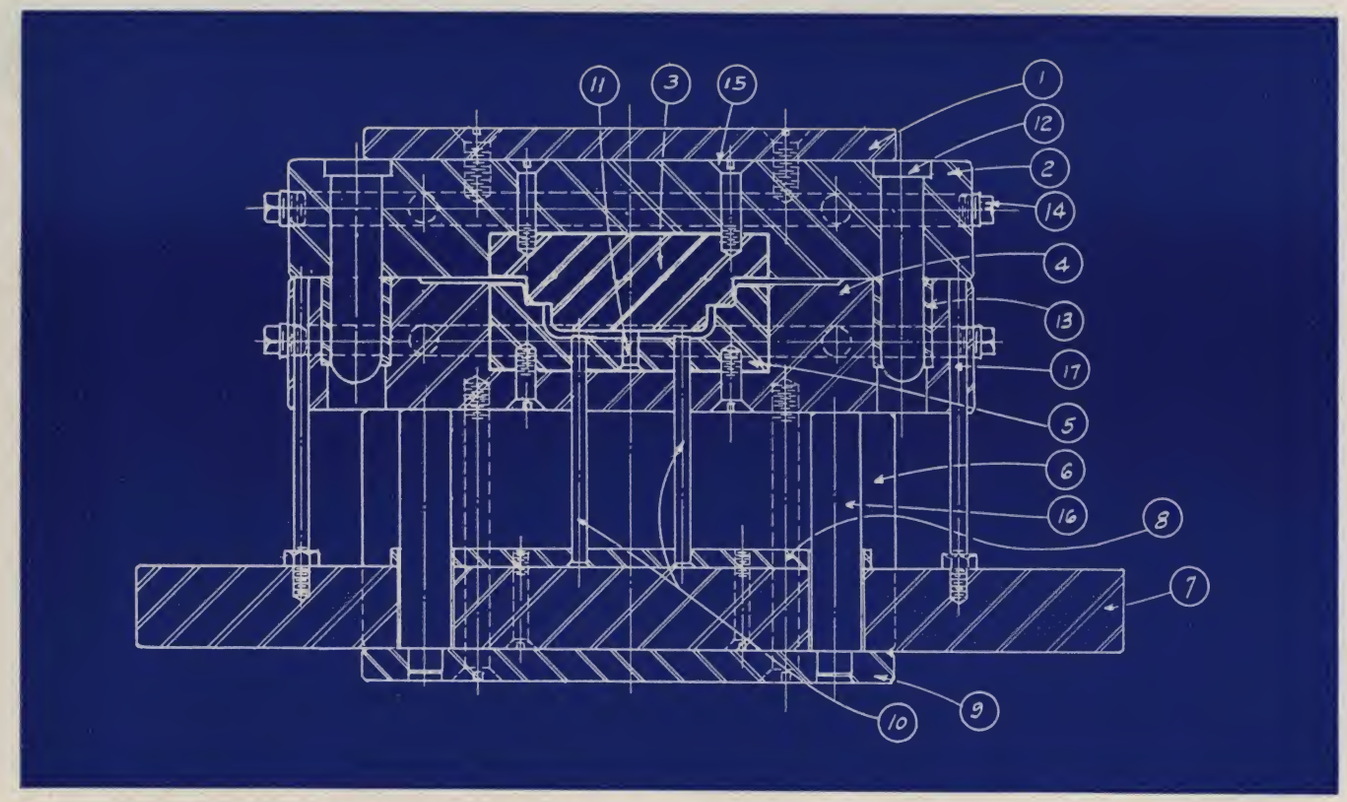
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pin bushings should be fastened securely and ground to tolerances that will allow the minimum of side play and yet allow the top and bottom members of the mold to slide together freely. Recesses for locating the plunger and cavity in the steam retainer shoes should be machined to the same size so that the plunger and cavity may be ground together, assuring as good a line-up as possible when the mold is assembled. Support pads should be placed on the bottom steam retainer shoe, at the same height as the top of the cavity. Thus, when the mold is closed, the pressure will be distributed over a greater area than the cut-off area of the cavity itself. The designer should carefully check the spread between parallels, and if it is too great to withstand the molding pressure, suitable support should be provided under the bottom steam retainer shoe, either in the form of support pins or parallels. These extra supports should be designed to withstand the pressure of molding; also, the knockout bar should be checked to see that these extra openings through it have not weakened it, permitting it to bend under the ejecting pressure. Knockout pins should be fastened to the bar by means of a pin retainer plate. The holes through this pin retainer plate should be larger than the body diameter of the knockout pins to allow the pins to move as the steam retainer shoe expands under heat. Steam lines should be placed around the cavity and plunger and also beneath them wherever possible. If it is necessary for mold pins to enter the plunger in order to keep them straight, due to their small diameter, or to maintain them at right angles to the bottom of the cavity, a clean-out slot should be placed between the top plate and top retainer steam shoe. It must be of sufficient depth and width to allow easy cleaning of any excess material which may be pushed up ahead of the pin in the molding operation. All sections of the mold should be securely fastened together with screws of a size that will withstand the continual pressure applied in closing and opening the mold.

Landed plunger mold.—A landed plunger mold (Fig. 2) is designed the same as a flash mold with the exception that the cut-off of the material takes place at a predetermined distance below the top of the cavity. This allows for better line-up between the plunger and cavity, which is extremely necessary where thin walls are to be molded. Due to the plunger entering the cavity outside the cutoff, and consequently locking the material in the cavity, it is frequently necessary to provide space for excess material to flow up the sides of the plunger in order that the mold may close and produce a molded part within the required dimensions. The designer should anticipate this condition whenever possible, but if in doubt, this relief should not be specified, but will be determined at the time the mold is sampled. If too much relief is put on the mold, an excess amount of material will be used in making parts, and also it may increase the difficulties in making satisfactory parts.

Loading plate mold.—The design of a loading plate mold (Fig. 3) is the same as that of a flash mold, with the exception that a loading plate is placed on top the cavity and bottom steam retainer shoe. The object of this loading plate is to provide extra space for loading material to be molded without having to cut this extra depth in the cavity, and also to allow shorter knockout pins to be used, as the loading plate is designed to be carried on the top half of the mold as the press is opened. This is done by letting the loading plate ride on guide pins fastened in the top member of the mold. They must be long enough to pass through the loading plate and

Fig. 2. Landed plunger mold



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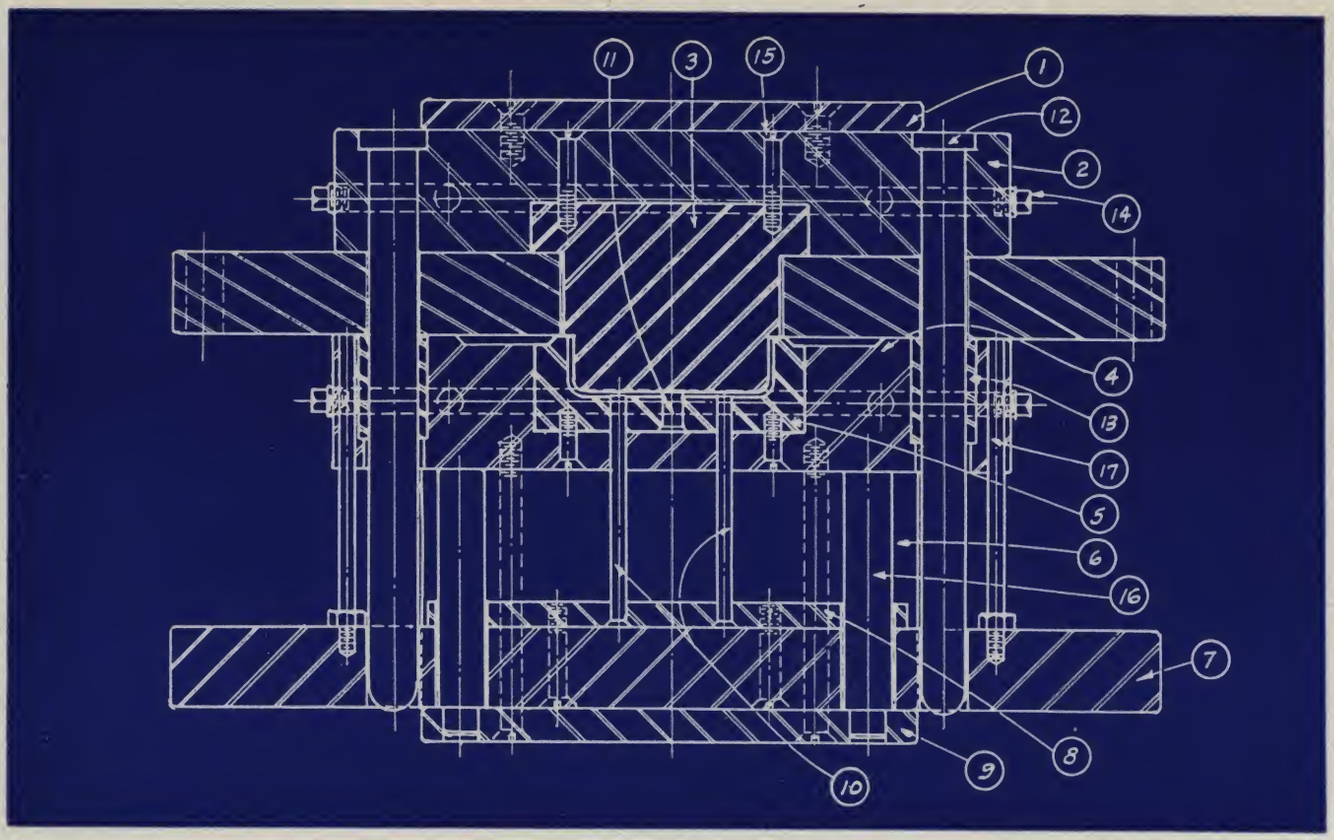


Fig. 3. Loading plate mold

enter the bottom half of the mold before the loading plate comes into contact with the bottom steam retainer shoe. The loading plate should be of sufficient length to allow rods to be attached to each end for the purpose of pushing down, and this downward movement is stopped by shoulder screws fastened into the top member of the mold. When a loading plate mold is completely open, the designer should have allowed sufficient space for the operator to work between the bottom of the plunger and the top of the loading plate.

Straight plunger molds.—Straight plunger molds (Fig. 4) differ from flash molds only in that the plunger enters the cavity to a pre-determined depth, completely filling the cavity opening so that when full pressure is on, the molded material is taking the full load of the press. This type of mold makes it very difficult to mold parts within close overall tolerances but does give a part of greater density than any of the other types.

Two-ram or angle-press molds.—Two-ram press molds are either landed plunger or straight plunger in design, with the addition of a moving member fastened to a ram that moves at right angles with the top ram of the press. The main point to keep in mind in designing a mold for the two-ram press is to make the supporting members holding the cavities and plungers sufficiently strong, and to provide interlocks so that when the side ram is closed, the bottom plunger and two side parts are locked into an immovable unit. This is extremely important. From the time the side ram is closed the mold becomes, in action, the same as a landed plunger or straight plunger mold. However, there is another difference and that is in the knockout arrangement. This is usually accomplished by removing a sliding tray with the molded part on it after the mold is opened. The molded part is then removed from the tray by other mechanical means outside the press. When a sliding tray is not required, the bottom member slides away from the cavity walls in the direction of the side ram until stopped in the unloading position by means of stop screws. The molded part is then removed by means of a hand ejector.

Injection molds.—Molds for materials that are used in the machines for injection molding require a different design technique than molds that use materials of the compression type. The mold must be designed to go into a rather limited space, since the strain rods on the machines are fairly close together. Extremely high pressures are developed in these machines and ruggedness of construction with maximum support must be kept constantly in mind. The location of sprues, size and location of gates, must also be given careful consideration. Where movable side members, slides, and cores are used, maximum support and method of controlling movements should be thoroughly gone into by the designer. It is also of considerable advantage, where line-up is important, to use interlocks, and these should be, whenever possible, an integral part of the mold.

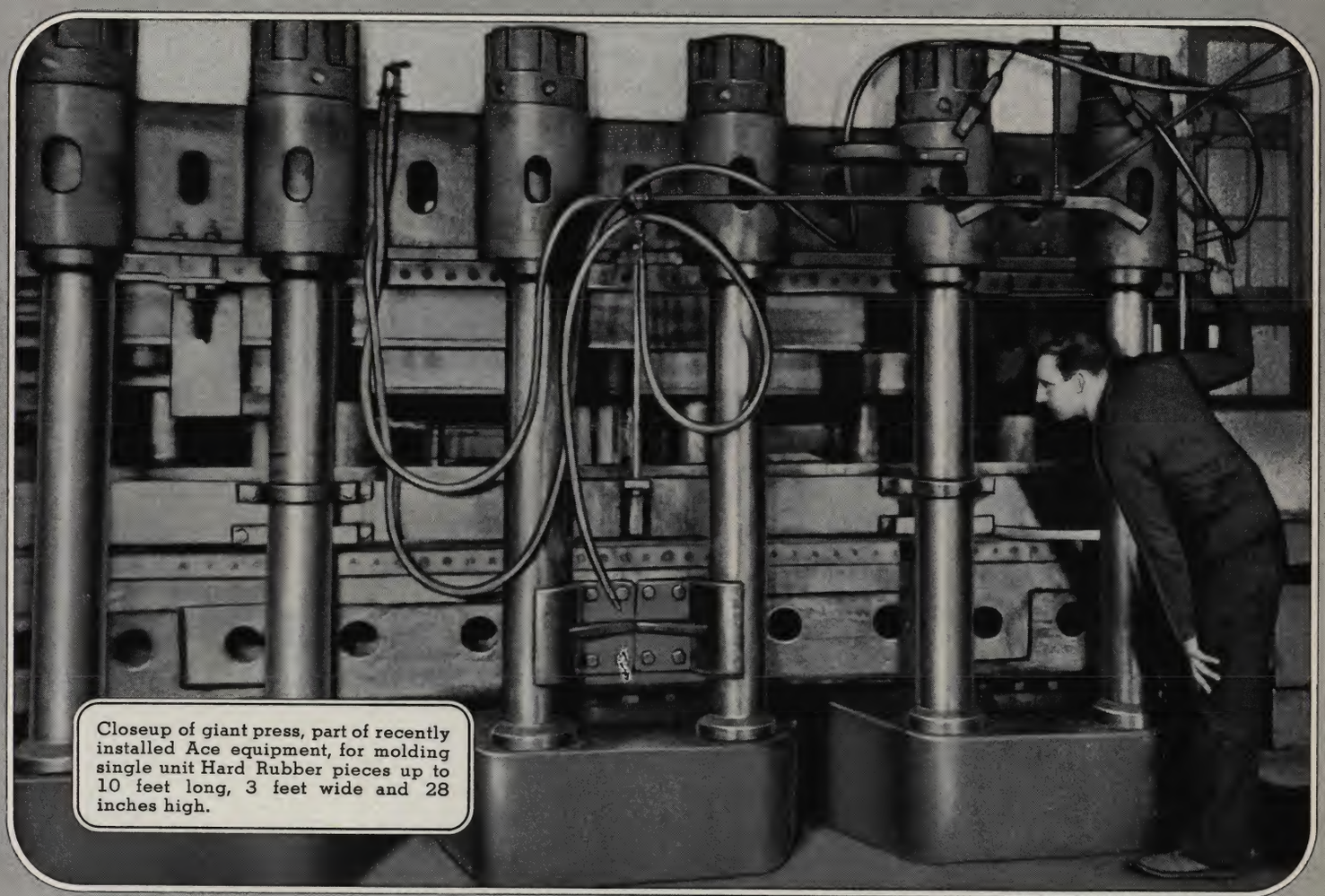
In the design of a mold of any of the types mentioned, the designer should take into consideration the following items:

Number of cavities; Size of press required; Type of material to be used; Whether loading into the mold will be in preforms or bulk; Loading space required; What the shrinkage allowance is for the particular material used; Where to put the guide pins and how

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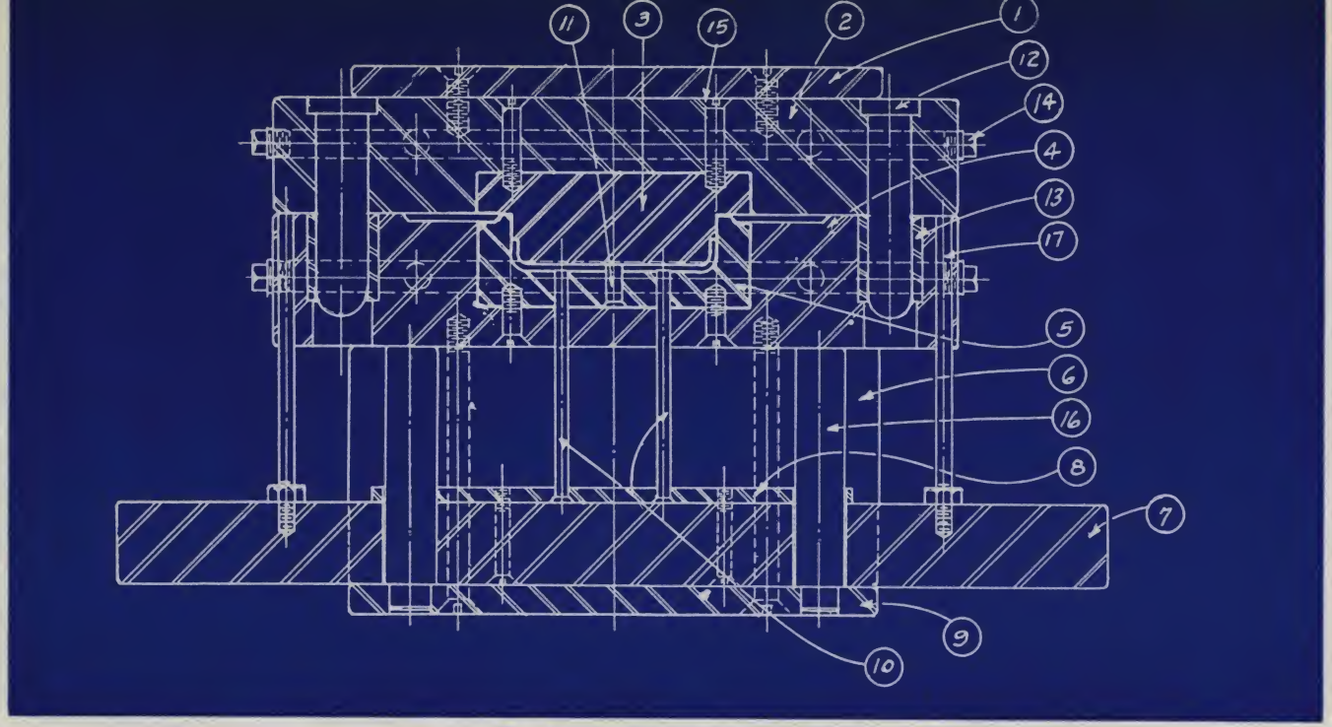


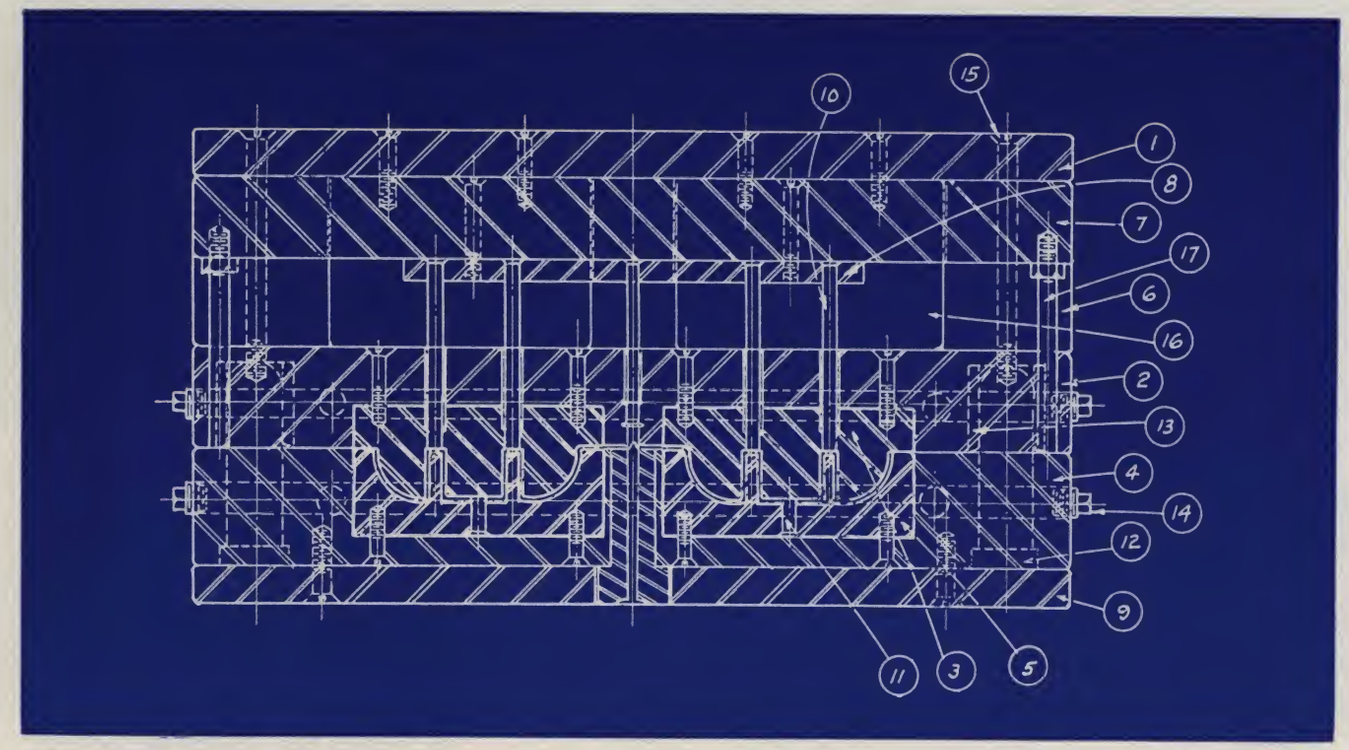
Fig. 4. Straight plunger mold

many; Where to channel the mold for heating; Number, size and location of knockout pins; Are the pins that mold the holes of correct diameter for the depth of hole to be molded; Are wedges required, and how shall they be located in the mold; Are pull pins required; Shall the mold be built in sections or in one piece; Where shall draft be allowed and how much; etc.

The designer should always keep in mind the ultimate cost of the tool but not at the expense of the part which is to be produced.

Number of cavities.—A difference of opinion prevails as to the correct number of cavities which may be put into a mold, as in Fig. 6, to give the maximum efficiency and the lowest cost of parts produced. In deciding on the number of cavities to be built into a mold the first information required is the number of molded parts required by the customer over a period of three months or longer, and what his daily or weekly requirements will be. If these requirements are very small, usually a single cavity mold will be large enough to take care of production. As the quantity to be ordered increases, it will be necessary to increase the number of cavities in the mold to the point where the individual molder feels he can realize the greatest output from his press equipment at the lowest cost. It is quite often necessary to limit the number of cavities in a mold due to the size of the part to be molded, or to the design of part to be molded. In such

Fig. 5. Sub-cavity type mold



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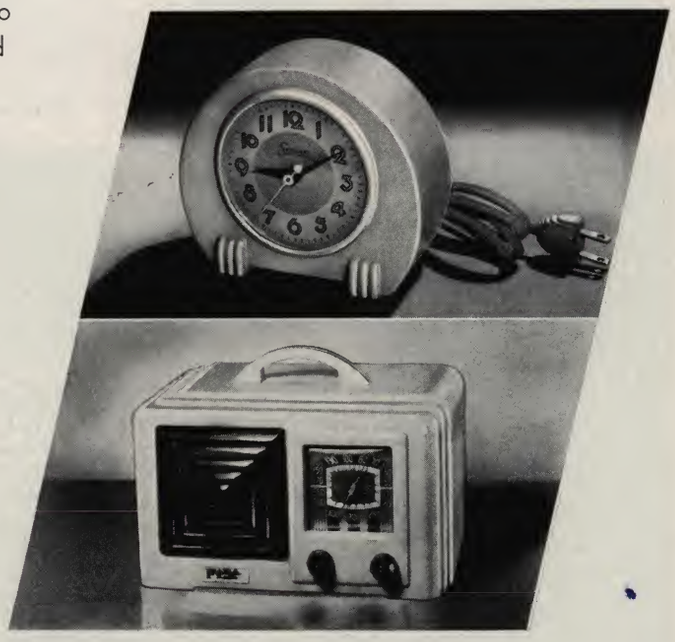
Your product, progressing from blueprint to molding press, has behind it the concentrated effort of the entire Stokes organization.

Here are design engineers who create and develop appealing designs that are thoroughly practical for economical molding.

In addition, a fully equipped machine shop together with ample molding equipment, adequate in size and versatility, assure you speedy, uninterrupted, low cost production that meets delivery schedules without a hitch.

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MOLDERS OF ALL PLASTICS—Including Hard Rubber—SINCE 1897

cases if the number of cavities required is more than can be put into one mold, additional molds will have to be built. Another limiting feature in deciding on the number of cavities to be made is the platen area of the available press equipment, and the tonnage delivered to the platen by hydraulic pressure or other means with which the individual molder's plant is equipped.

Size of press required.—Press size as discussed here is the amount of tons per square inch which can be produced by a ram actuated by hydraulic pressure or other means. Considerable care must be taken in designing a mold to see that the mold will fit into a press with adequate pressure. If too low a pressure is used, the molded parts will be inferior in quality and extra time will have to be spent on finishing operations. On the other hand, too much pressure may readily result in damage to the mold, which means high mold maintenance and loss of production. Different types of molding materials may require different pressures to mold satisfactorily, so the designer must thoroughly check the material to be used.

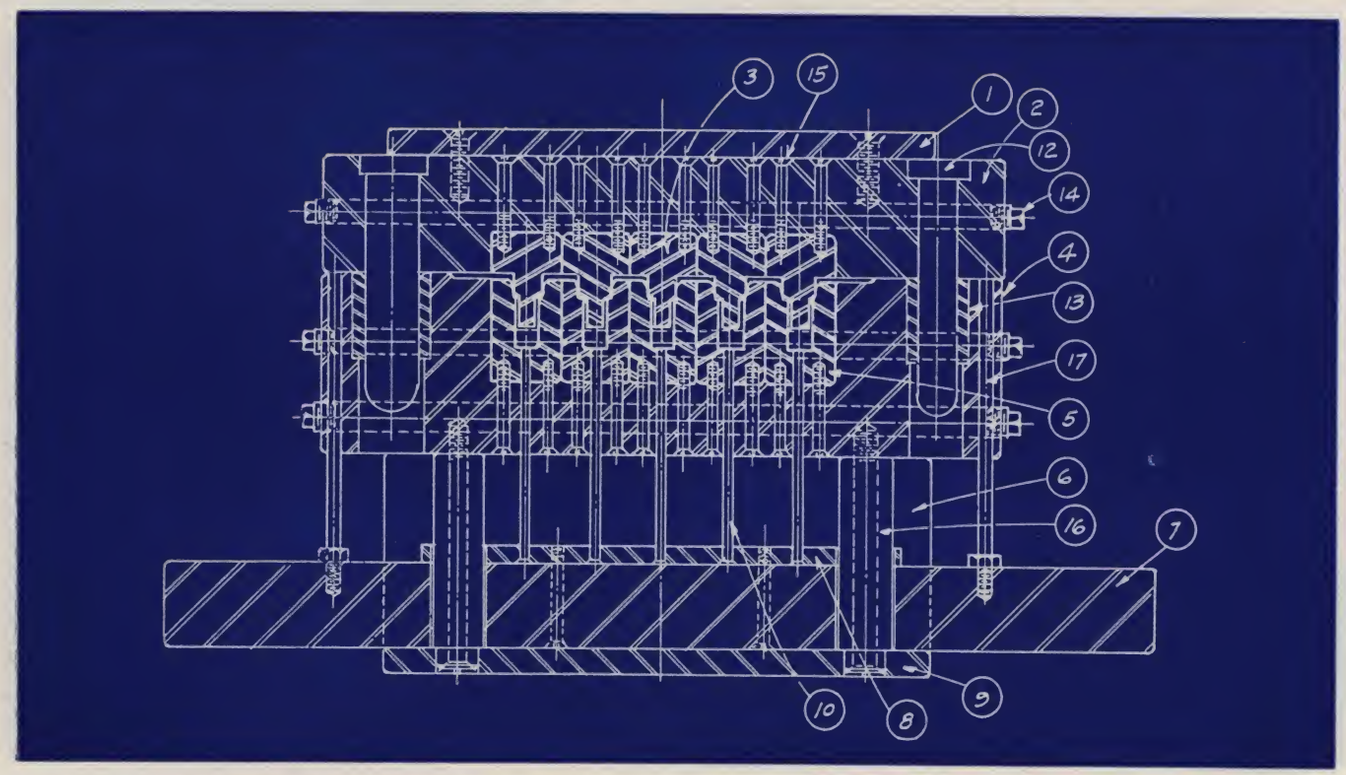
Type of material.—There are a great many different types of materials used in molding, and some of them require more filler or loading space designed into the mold than others. If preforms are to be used, less loading space is required, also, than if the material is loaded in bulk. It is well to keep the loading space of a mold to minimum requirements in order to make the mold less costly. If mold pins are required to enter the plunger, it is an advantage to keep the loading space down, as damage to the pins is less likely to occur, due to their shorter length, and consequently, greater strength.

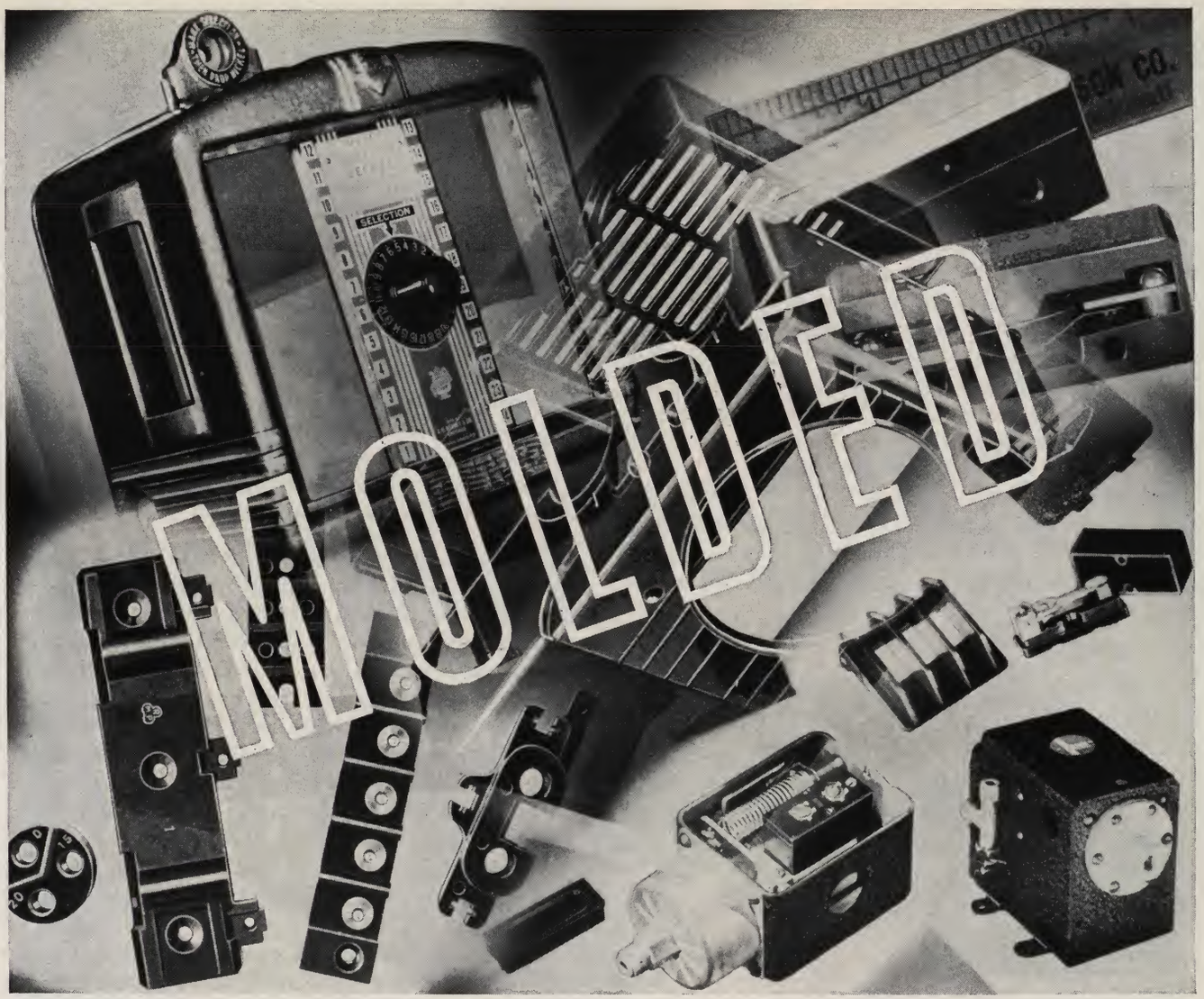
Shrinkage allowance.—Manufacturers of molding materials have, and are continually making tests to determine the shrinkage allowances that are to be used for the various types of materials which they produce. These shrinkage allowances must necessarily be an average of several tests as different batches of material may show different shrinkages, and a figure must be arrived at which will show the least variation after the material is molded. The designer adds the correct amount of shrinkage per inch to the dimensions which he puts on the drawing or sketch from which the tool is to be made, and if the tool is made to these dimensions it may be expected to produce a molded part within the tolerances provided on the part drawing, if the tolerances on the part drawing have been added by a draftsman familiar with molding practice.

Tapers.—An extremely important factor which is oftentimes overlooked is the placing of taper, or draft, on all parts wherever possible. If a molded part requires straight sides, it can be done, but with much more difficulty than if taper could have been allowed. This subject of taper should be thoroughly discussed with the customer so that an understanding can be arrived at before the mold is designed and built.

In summing up the subject of design of molds it can readily be understood that designers of actual mold making experience, molding experience, and other functions of a molding plant, are necessary in order that the individual molder can satisfy his customers with a quality product at a satisfactory price.

Fig. 6. Number of Cavities





INSUROK

Intricate and involved are many of the precision molded pieces that come from Richardson presses. They require a high degree of skill in the design and manufacture of dies and molds, and a distinctive molding technique. Yet, they are all in the day's work for Richardson, where mass production molding to exact tolerances is everyday procedure. Your molded requirements, however exacting, are fully met with INSUROK, the precision plastic. Literature on request.

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Construction of molds

NO INDUSTRIAL group has contributed more toward perfecting the art of molding plastics than the domestic manufacturers of tool steel. The time was when tool makers largely relied upon foreign sources, and it wasn't so long ago that many deficiencies such as non-uniformity and impurities were inherent in the then available tool steels. Today metals for molds may be purchased to rigid specifications.

Steel for molds*

With the rapid growth in the manufacture and use of molded plastics articles, the problem of steel for molds has had much study by both steel users and steel manufacturers. As has been the case in other industries, the requirements of certain types of dies have made it desirable to develop a number of special steels. Here are some of the factors which may influence the choice of a steel for molds:

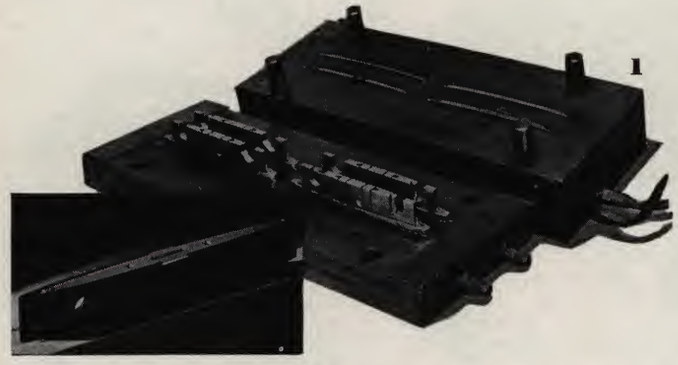
1—Size and finish required in the molded part.
2—Number of pieces to be manufactured.
3—Pressures used in forming.
4—Corrosion and erosion characteristics of the plastic.
5—Cost of manufacturing the dies.

Obviously, in cases of short runs where finish and size tolerance are not important, inexpensive mold steels are economical—such steels as Open Hearth Ingot Iron, Machine Steel and such S.A.E. analyses of the case-hardening type as Nos. 3110, 4610, 5110 and 6110. Originally these steels enjoyed a very large use in plastic molding. However, with the introduction of plastic parts of higher quality, where large size, close tolerance and good finish were required, the use of better grades of steel was found to be economical. With this in mind, steels having special properties have been developed. Some of the properties which have been studied and must be kept under control in the manufacture of steel for high quality molds, are as follows.

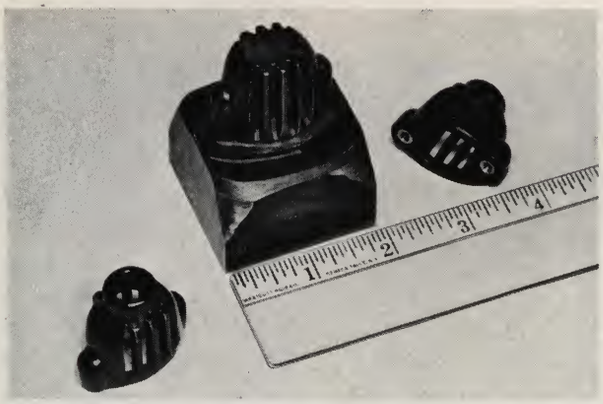
1. *Cleanness.* The presence of non-metallic inclusions in mold steels leads to the manufacture of molds which contain pits or longitudinal lines. This condition is very undesirable in the production of molded parts which must have a high finish. To avoid this condition, the highest quality mold steels are melted by the electric furnace process under special conditions to insure cleanness and freedom from non-metallic inclusions. Cleanness is further checked by an acid disk inspection.

2. *Uniformity.* Uniform analysis is essential in order to secure accurate response to delicate hobbing operations and to heat treatment. The microstructure of the steel is important because it has a definite bearing on the ability of the steels to machine cleanly or to hob uniformly under a given pressure.

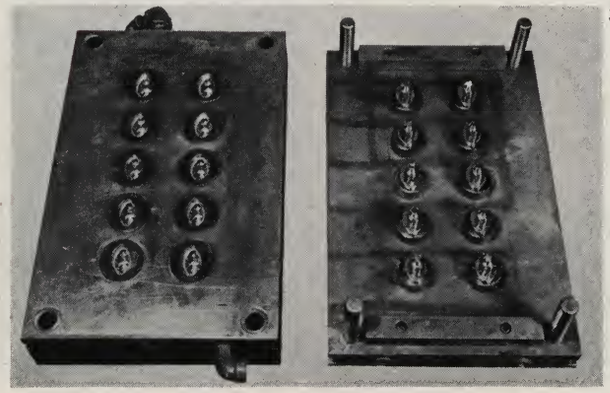
3. *Machinability.* Certain mold steels must withstand extremely high pressures in service. They are apt



1



2



3

* This section was especially prepared for this issue by W. H. Kemper, Med. Dept., The Carpenter Steel Co.

1—Perfection of surface of this molded pocket-size Torpedo Level is achieved through highly polished, smooth, clear, flawless steel molds. Finished part (inset) demonstrates these factors. (Photo, courtesy Carpenter Steel Co.) 2—Hob machined by Chicago Molded Products Corp. from Chrome Tungsten Vanadium tool steel to make the 10-cavity-mold for the phenolic part shown. 3—All 10 cavities in the mold were cold hobbed and machined to final finish

The Boonton Press

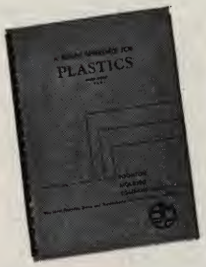
(PUBLISHED IN THE INTERESTS OF BETTER MOLDING AND MORE BUSINESS)

MOLDING PLANT IN SEARCH OF CUSTOMERS

BOONTON, N. J., Everyday, 1941.—One complete molding plant, known as the Boonton Molding Company, containing within its well-designed interior, numerous injection and compression molding presses of all sizes (but all modern) for the molding of today's thermo-plastics and thermosetting plastics, mentioned that it had room for a few discriminating customers.

"I have plenty of satisfied customers," the plant said, "who use me as their own molding department. That's the kind of service I have to offer to some *more* people who demand service, on-time deliveries; who expect me to solve their difficult problems and are willing to give me their whole-hearted cooperation in the solution. I like to make an honest profit and I pay my boys what they're worth (they work hard enough for it, Lord knows) so no job takes precedence over any other because of a more tempting profit margin.

"I'm equipped to handle an order of 100 parts or a million equally well and with equal efficiency. And one more thing. I'd like my prospective customers to look me over. Come up and see me some time. I'm running 24 hours every day and I'll be glad to talk to you and show you around."



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BOONTON MOLDING COMPANY

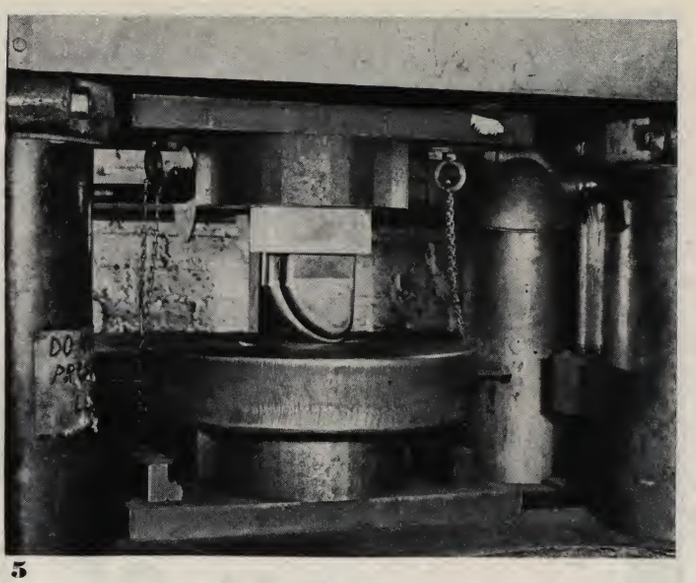
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4



5

4—This 3000-ton Baldwin-Southwark hobbing press with welded housing exerts a tremendous pressure to force a hardened steel hob into a soft, cold steel block. 5—Hobbing die sinking down to form an exactly reproduced mold cavity

to be difficult to anneal and difficult to hob uniformly and accurately. Accordingly, such steels are frequently machined to size. Clean machining characteristics—i.e., the ability to have a smooth surface after cutting—are therefore important. This ability will depend on the hardness of the steel in the annealed condition and on its microstructure.

4. *Hobability.* Intricate molds are usually cold hobbed to size. So steels for hobbing must be as soft as possible, a feature which is in some contradiction to the requirement for machinability mentioned in No. 3 above. Other things being equal, the "hobability" of the steel is influenced by its analysis. Ingot irons and low alloy materials hob more readily than steels containing alloys. The higher the alloy content (including carbon), the more difficult the hobbing operation becomes.

5. *Hardenability.* Mold steels must acquire in heat treating a hard, uniform, strong surface and a tough, strong core. Ingot irons and machine steels containing no alloys are of necessity hardened in water and may distort. They are also subject, in the case of large molds of certain designs, to soft spots in the case. On the other hand, some of the alloy steels can be hardened in oil with good results, a feature which is desirable from the standpoint of size-change during hardening. Steel containing alloys are also less subject to soft spots in the case.

6. *Strength and toughness.* The hardness and strength of both the hardened surface and the toughened core of the steel are important where the plastic requires high pressure for proper forming. Here again analysis is the governing factor. For high mold strength and resistance to shrinking or premature spalling of the surface, alloy steels prove superior to low carbon ingot iron.

7. *Heat treating safety.* Steel which will be free from soft spots in hardening and which, at the same time, is less likely to warp or break in heat treatment, is desirable. The cleanness of the steel is nearly as important from this latter standpoint as from the standpoint of finish. To prevent size-change and warpage, alloy steels which will harden in oil are desirable. This feature, in the case of very large dies, is so important that it is the practice in some highly specialized shops to purchase alloy steels already hardened to the limit of machinability. Such dies are machined to size and used without further heat treatment despite the machining expense which is, of course, high when using this type of manufacture. However, the accuracy to size and quality finish insured by eliminating the final heat treating are considered to be worth the extra expense.

8. *Good finishing qualities.* The hardened die should be able to take a mirror finish after proper heat treatment, and hold it in the face of the abrasive effect of certain types of plastic compounds. Some of the compounds used are also distinctly corrosive to ordinary steels. Where these materials are handled, special attention should be given to corrosion-resisting steels.

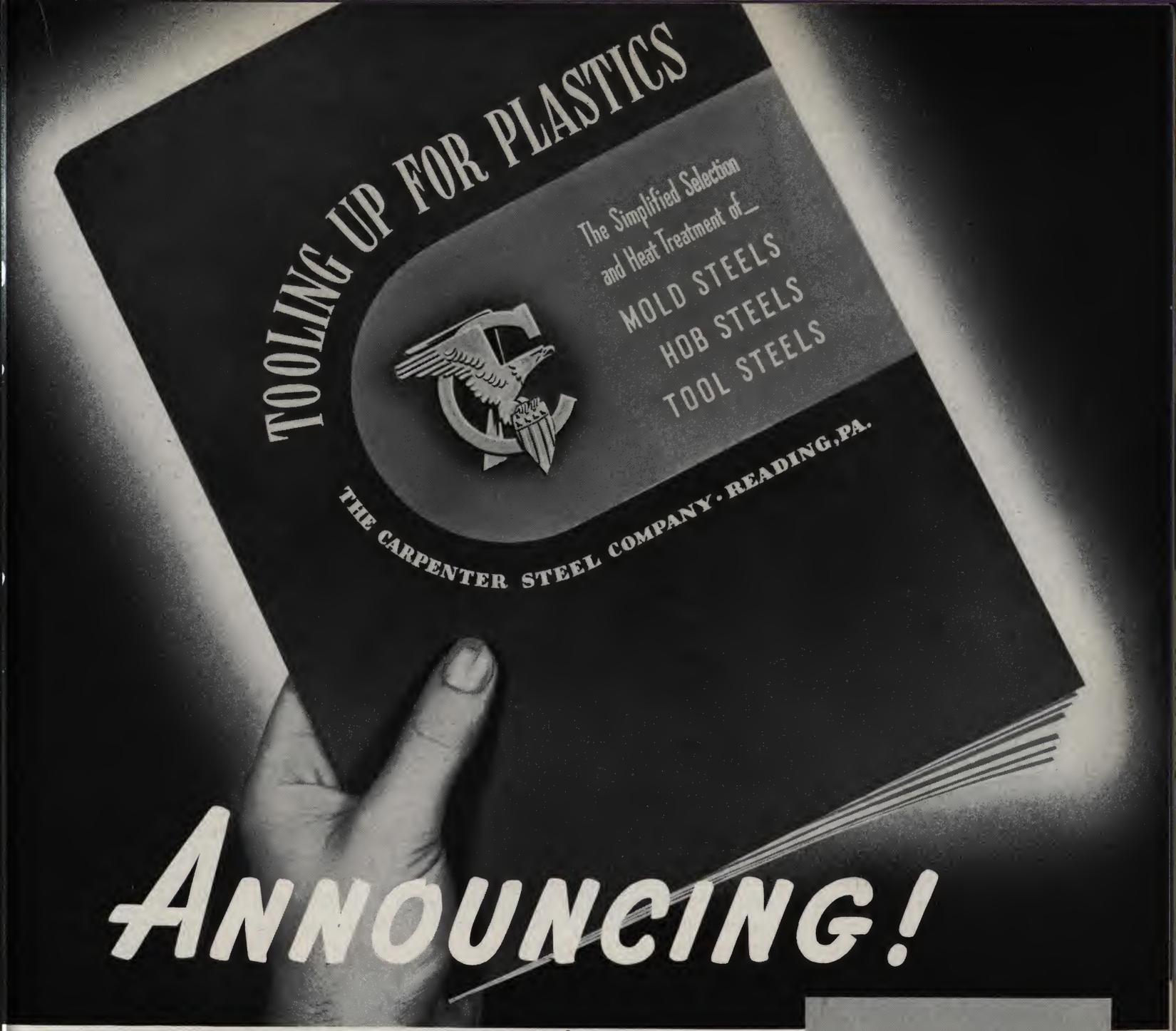
In summarizing, it might be pointed out that items Nos. 1 and 2 and, to some extent, Nos. 5, 7 and 8 require high quality steel melted in electric furnaces. It should preferably be acid disk inspected to insure cleanness. Points 3, 4 and 6 and, to some extent, Nos. 5, 7 and 8 will vary with the particular type of steel decided upon and the individual requirements of the work.

Table (page 166) describes five types of steels which are being successfully used for mold manufacture.

Some valuable hints which will assist in producing satisfactory molds are as follows:

1. In the absence of other information, heat treating instructions can be secured from the manufacturers of the steels and should be carefully followed. However, a study of mold heat treatment as applied to individual practice will frequently result in very much improved service. If a large number of molds are to be manufactured, such study is highly recommended.

(*Please turn to next page*)



ANNOUNCING!

This New, 36-Page Book on Steels for Plastic Tooling

For the first time, you can now get in book form a summary of modern practice on selecting, heat treating, and using steels for molds, hobs, and plastic working tools. More than half the information contained in "Tooling Up For Plastics" has never before been published in any form.

If you want to know the standard practice on pressure relieving of mold blanks for hobbing • How you can prevent scale or scum on polished mold surfaces during carburizing or during hardening • Which steel should be used to prevent excessive size change • Whether oil-hardening or air-hardening steels are best for hobs • Why South American molders are turning to *stainless steel* for molds, and which stainless steels . . . Here is where to find the answers.

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MOLD STEELS

CONTENTS

*Simplified Mold Steel Selection

Alloy Mold Steels (Properties, heat treatment)

*Stainless Mold Steels (Properties, heat treatment)

*Simplified Hob Steel Selection
Air and Oil-hardening Hob Steels
(Properties, heat treatment)

*Common Questions and Answers

*The Matched Set Method Applied to Plastic Working Tools

The Processing of Plastics

Convenient Tables and Charts

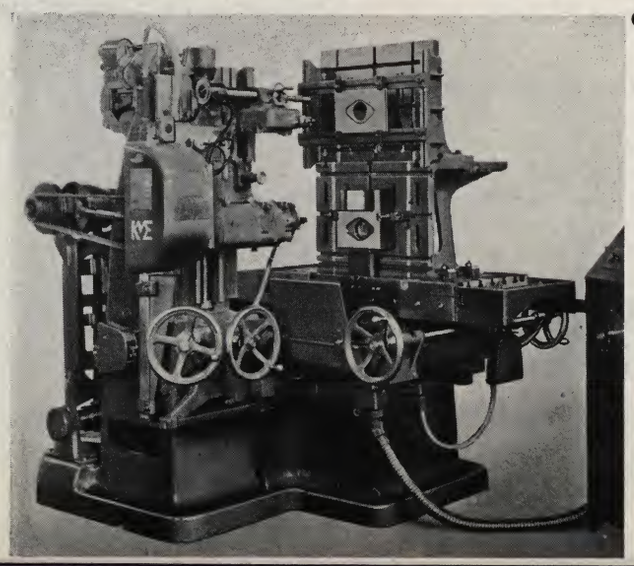
**Includes New Information Not Previously Published Elsewhere*

Table I. Properties of Steels for Molds and Hobs

	Case-Hardening Ingot Iron	Case-Hardening Mold Steel	Case-Hardening Mold Steel	Super Case-Hardening Mold Steel	Oil-Hardening Tool Steel
Machinability	Tough and stringy	Tough	Good—about like S.A.E. 1020	About like tool steel	Same as high carbon tool steel
Hobability	Excellent	Good	Fair	Difficult	Very difficult
	Brinell = 90 max.	Brinell = 120 max.	Brinell = 160 max.	Brinell = 200 max.	
Hardenability					
Hardness of Case	Rockwell C 62–64	C 62–64	C 62–64	C 62–64	C 63–64
" " Core	" B 90	B 100	C 30	C 35	C 60–62
Strength					
Core: Strength Tensile	Lowest 90,000	Low 105,000	Medium 125,000	High 150,000	No core
Cost	Lowest	Low	Low	Medium	Highest
Uses	Short runs, plain hobbed cavities, low molding pressures	General molding hobbed cavities, medium to long runs	General molding machined cavities, medium to long runs	Very large molds, high molding pressures, very long runs	Close tolerance molds and intricate molds where size change or warpage must not occur
General Analysis	C .10%	C .10% Mn .50% Cr .50% Ni 1.25%	C .20% Mn .60% Cr .50% Ni 1.25%	C .10% Mn .30% Cr 1.50% Ni 3.75%	C .90% Mn 1.00–1.60% Other alloys optional

2. Cases have been observed where blue vitrol (copper sulphate) solution often used for laying out the cavity or as a lubricant during the hobbing operation, will leave a deposit on the mold surface. Unless removed, they are likely to result in soft spots during hardening. Deposits of copper may be best removed by using a solution of potassium cyanide—a practice which is well understood by most tool makers. Nitric acid may also be used, but if this solution is employed, great care should be taken not to etch the mold cavity. Molds should be cleaned thoroughly before hardening with carbon tetrachloride, and care should be taken to absolutely avoid any grease or foreign matter on the face of the mold. Failure to insure clean cavities before and during hardening is a prolific source of surface defects.

6—Large size vertical type Keller Duplicating Machine typifies this class of highly efficient specialized equipment. (Photo, courtesy Pratt & Whitney Co.)



6

3. It should be borne in mind when hobbing a mold that the smoothness of the mold surface is a reflection of the smoothness of the metal before hobbing and of the smoothness of the hob. Some manufacturers make a general practice of polishing the surface of the metal before hobbing. This procedure is highly recommended.

4. When polishing molds after hardening, care should be taken to use a compound which *cuts* the steel as opposed to burnishing it. The best practice is to polish by working from a heavy emery down to a Turkish flour. Rouge or similar burnishing compounds are not recommended since burnishing, unless very carefully done, is likely to tear small particles from the metal which leave defects, roughen the polish, and tend to scratch the mold.

Tool steels for the manufacture of hobs. The necessary properties of a tool steel for the manufacture of hobs may be summarized as follows:

(1) Good machining qualities in the annealed state.
(2) Ability to be hardened with a minimum of warpage and size change.
(3) Great strength in compression and high transverse strength in tension in the hardened condition.
(4) High wear resistance in the hardened condition.

To meet these requirements alloy tool steels have been found to be most satisfactory as air or oil-hardening properties are essential. Here are some steels which are being successfully used for the manufacture of hobs and which fulfill the requirements: (*Please turn to page 171*)


The Entrance to
The MOST MODERN MOLDING PLANT in the WORLD!
CHICAGO MOLDED PRODUCTS CORP.
1020 N. KOLMAR



Drafting Room:
Where molds are designed. Here, at your service is a staff of engineers schooled and experienced in designing better molds for Plastic Molding.



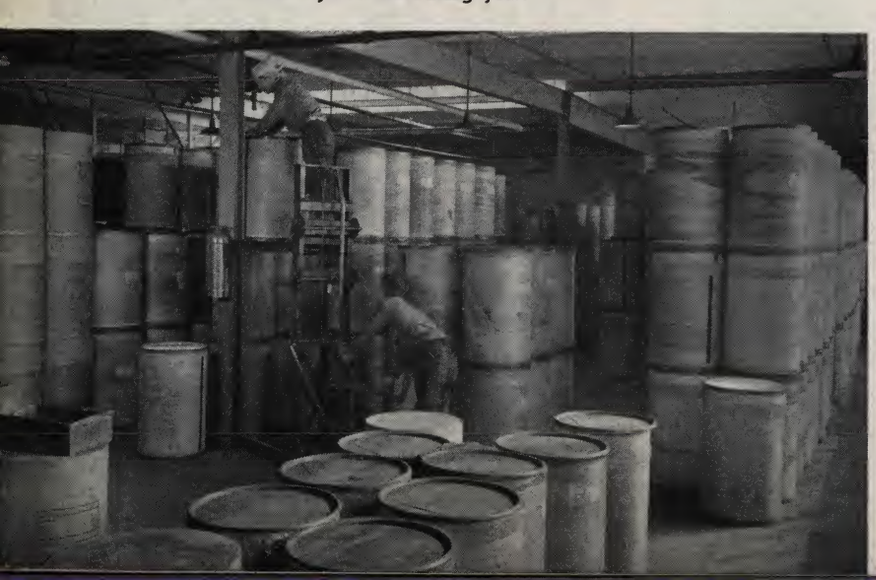
Tool Room:
Two views of the largest, best equipped tool room in the industry. Here 100 skilled craftsmen fabricate precision molds and tools for your compression or injection molding requirements.

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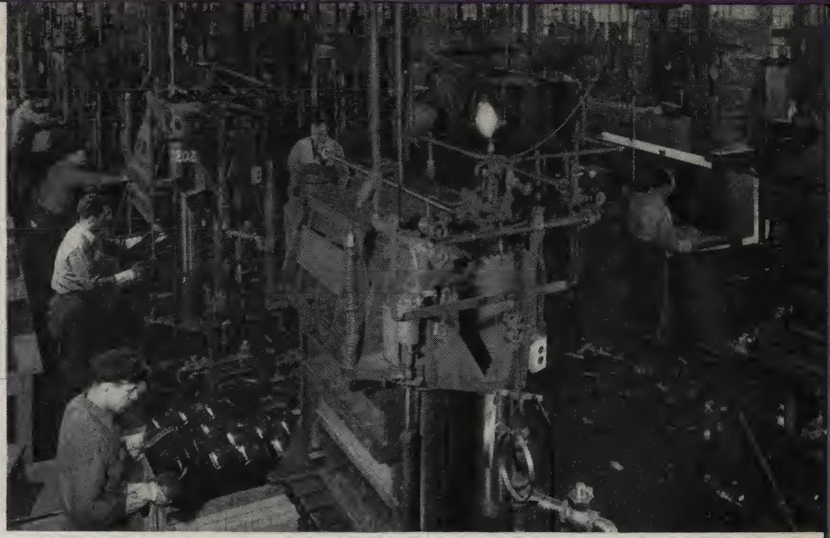
Material Supply:
A large and complete stock of all types of molding materials is constantly ready to be put into production on your molding job.

Finishing:
In addition to removing the flash or fin, to polishing and buffing, some molded parts require the drilling and tapping of small holes. Shown here is one of some thirteen multiple spindle drills capable of drilling or tapping 10 holes at one operation.

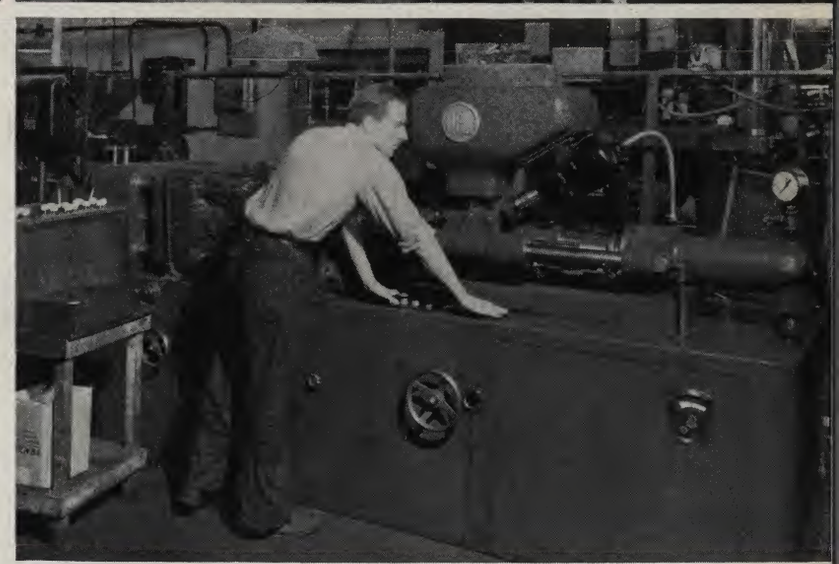






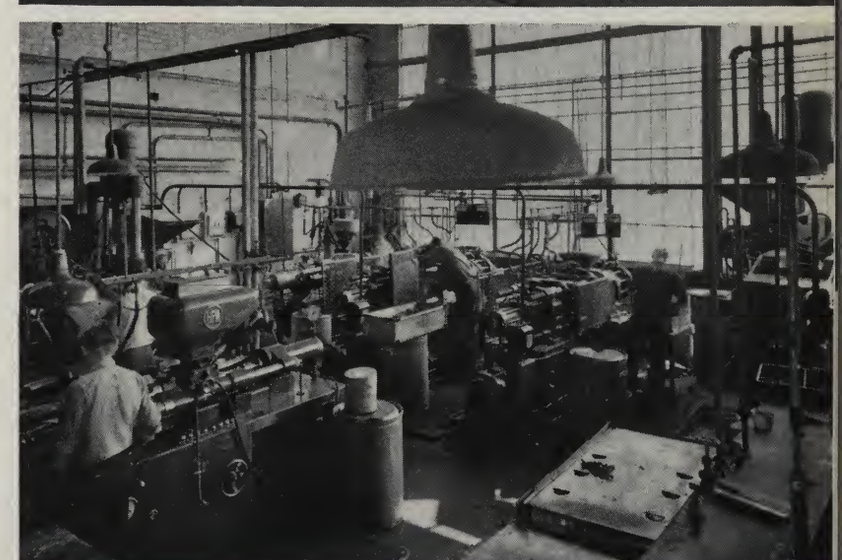


Compression Molding:
No photograph can do justice to our Compression molding room and the huge battery of presses in it. Here are approximately 100 modern hydraulic presses ranging in capacity from 100 tons to 750 tons pressure.



HAS EVERYTHING

Injection Molding:
Three views of some of our injection molding presses which range in size from 2 ounce to 12 ounce capacity. All are modern, high speed machines for the rapid and economical molding of thermoplastics.



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An all important factor in the production of satisfactory plastic molded parts is careful inspection. If our inspectors are over particular in regard to appearance, finish, dimensions and tolerances, it is to our customers' advantage and delight.



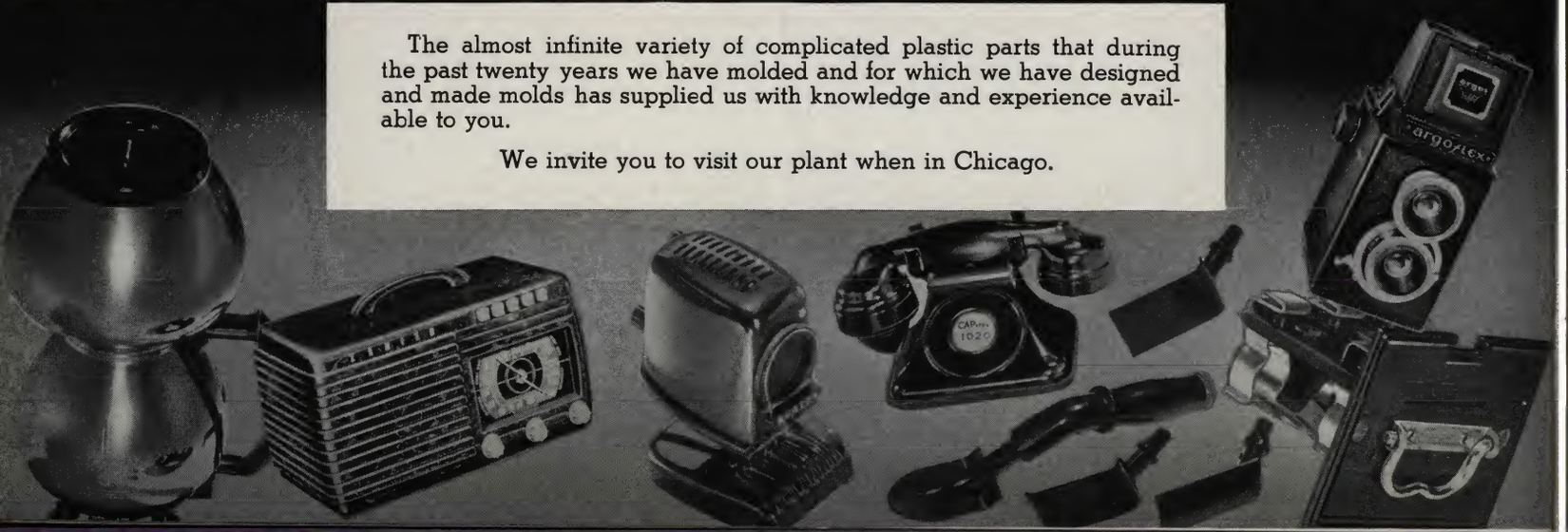




2½ ACRES DEVOTED TO PLASTIC MOLDING

The almost infinite variety of complicated plastic parts that during the past twenty years we have molded and for which we have designed and made molds has supplied us with knowledge and experience available to you.

We invite you to visit our plant when in Chicago.



(A) *Air-hardening steels:*

(1) A steel having analysis of 1.50% carbon
12.00% chromium
.80% molybdenum
.20% vanadium.

Hobs made from this steel are customarily hardened by heating in a pack of clean cast-iron borings or charcoal, to a temperature of 1850 deg. F. and cooling in air. Hobs drawn at 450 deg. F. will have maximum hardness and wear resistance with good toughness. Drawn at 700 deg. F., they will have maximum toughness and slightly less wear resistance.

(2) A steel analyzing 1.00% carbon
5.00% chromium
1.00% molybdenum
.20% vanadium.

Hobs made of this steel may be treated by packing in clean cast-iron borings or charcoal, heating to about 1775 deg. F. and cooling in air. A draw at 400 deg. F. will give maximum wear resistance with good toughness. Drawn at 700 deg. F., the steel is extremely tough with wear resistance and hardness slightly decreased. As would be expected, the wear resistance and toughness of hobs made from this steel are not quite as good as in the case of the first steel mentioned on account of the somewhat lower alloy content.

(B) *Oil-hardening steels:*

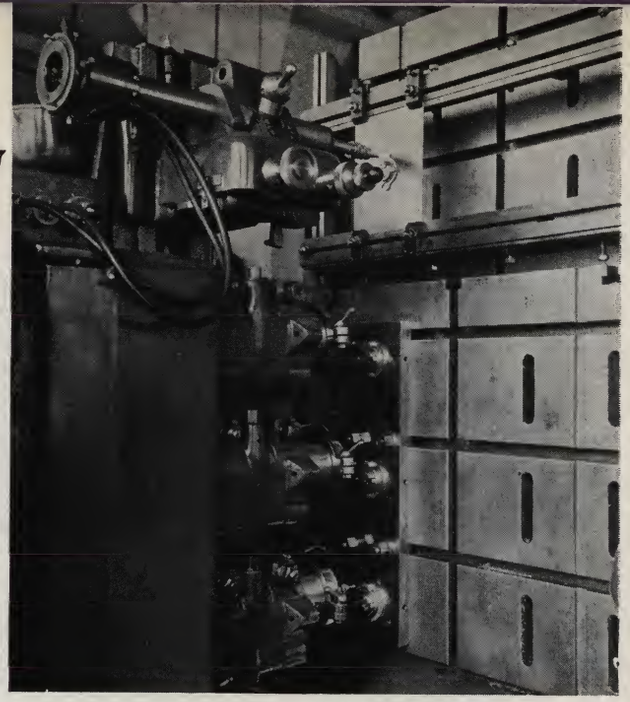
(1) A steel analyzing 2.10% carbon
12.50% chromium
nickel and vanadium optional.

Hobs made from this material are hardened by packing in clean cast-iron borings or charcoal, heating to a temperature of 1775 deg. F. and quenching in oil. Hobs drawn at 400 deg. F. have maximum hardness and at 800 deg. F. maximum toughness and slightly lowered hardness. This grade is the hardest and most wear-resistant grade of any of the steels described but it is not as tough as either of the air-hardening grades.

(2) A steel analyzing .90% carbon
1.00/1.75% manganese
tungsten, chromium and vanadium optional.

Hobs made from this grade are hardened by heating to about 1400 deg. F.–1525 deg. F., depending upon the exact composition. Pack-hardening in clean cast-iron borings or charcoal is recommended to secure the smoothest possible surface, though it is not absolutely essential. The hobs are drawn at 375–400 deg. F. to produce maximum toughness. This steel is the easiest to machine of all the steels described, and is a very good general purpose material to use for hob work. This steel is also used to manufacture certain types of molds.

(3) A steel analyzing .50/1.00% carbon
1.50% chromium
2.75% tungsten
.35% vanadium.



7—Keller duplicating machine with three spindle head producing three cores simultaneously from assembled template. (Photo, courtesy Pratt & Whitney Co.)

Hobs made from this material are hardened by heating to a temperature of about 1700 deg. F. and quenching in oil. Pack-hardening in clean cast-iron borings or charcoal is highly recommended to produce smooth surface. The hobs should be drawn back to about 400 deg. F. to produce maximum toughness and wear resistance. This steel has an extremely high compressive strength with fairly good wear resistance. It is not as easy to machine in the annealed conditions as steel No. 2 above.

(4) A steel analyzing .75% carbon
1.00% chromium
1.75% nickel.

The hobs are hardened by heating to 1525 deg. F. and quenching in oil, followed by a draw at about 300 deg. F. Here again pack-hardening is highly recommended to secure good surface. This type of steel has extremely high transverse tensile strength and is recommended for hobs that must resist unequal or splitting stresses. It does not become quite as hard nor have quite as good wear resistance as the other oil-hardening steels. It machines readily, however, and is a favorite for short runs where economy in hob manufacture is desired.

Hobbing*

Two factors enter into successful hobbing. The first is the hardened tool steel hob, which should have a slight taper or draft and may carry engraving if desired. Surfaces must be highly polished and undercuts avoided. The steel must be perfectly clean both physically and metallurgically. It should have no scratches or marks, no dirt on the surface or included in the steel, and it must have minimum porosity.

Since even a piece of lint will leave its mark if per-

*This section was submitted for this issue by G. F. Sullivan, Baldwin Southwark Div., Baldwin Locomotive Works.

mitted between hob and impression, this requirement for cleanness is important.

In general, other requirements for a good hob steel are:

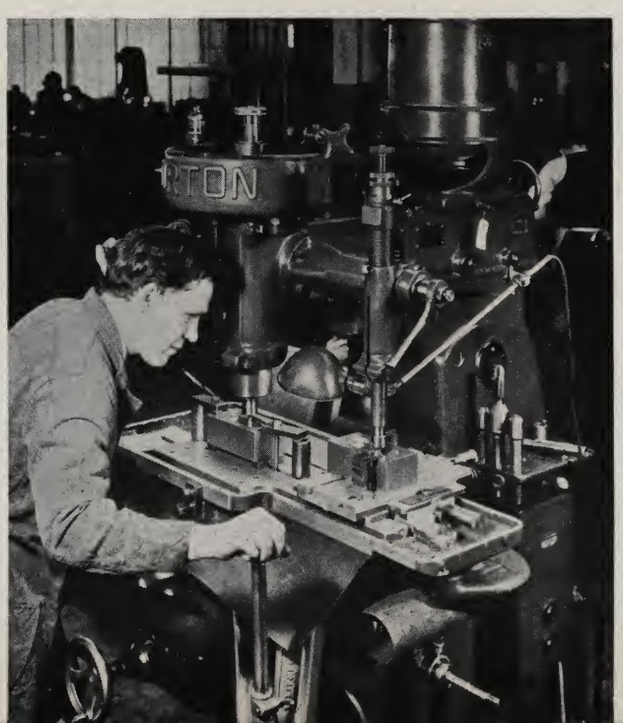
1. The ability to harden deeply with high compression strength and good hardness.
2. As much toughness as possible with the above requirement.
3. Minimum warpage or size change in hardening. (An oil-hardening grade.)
4. Minimum scaling when properly heat treated.
5. As good machining qualities as possible under the above requirements.

The choice of hob steels is also affected by the variables of the job—such as the number, depth and shape of the impressions to be made, the amount of stress relieving of the mold blank, the type of steel being hobbed, whether the blank is to be process annealed, etc. On certain jobs, it is good practice to pick the steel for great wear resistance at some sacrifice in toughness; for others, to select toughness at some sacrifice in wear resistance; and some jobs call for a steel about half-way between.

Ordinarily, blue vitriol, often applied over a light coat of penetrating oil, is used as a lubricant. Care must be taken to insure its complete removal from *both* hob and cavity after the impression has been made. For very high luster, lubricant is often omitted entirely.

The second factor entering into hobbing is, of course, the steel being hobbed—and this brings up the whole subject of mold steels. Elsewhere in this issue, the subject is covered in an article of its own. Briefly, however, the primary essentials are for a clean steel that will faithfully reproduce the hob and its finish, and for a steel that will flow freely, case harden deeply and easily and stand up well in service. Low-carbon machinery steel is sometimes used, but is less reliable and likely to be more expensive in the end. As shipped from jobber stocks, machinery steel is likely to contain hard spots or be otherwise improperly annealed. Its variations in carbon content make it difficult to judge hobbing pressures, as even a few points' difference may double the pressure required. Furthermore, it is nearly impossible to know whether or not the steel is clean until after the cavity has been hobbed, heat treated and given its final polish. Occasionally, the trouble does not show up until a few hundred parts have been molded. That is why acid disk-inspected, electric-furnace melted, low-carbon ingot irons and alloy tool steels, specially developed for good hobbing qualities, are most generally used. They also assure longer mold life and better finishes.

8—Gorton duplicator cutting plastic mold from existing steel master. One master permits the reproduction of indefinite number of duplicate cavities. (Photo, courtesy George Gorton Machine Co.)



8

Duplication of Molds*

In the early days of the plastics industry, molds were considered a necessary evil, and their production left to the devices of the individual skilled mold maker, working on such general purpose equipment as he had available. Management paid little attention to the problem. The rapid growth of the industry, however, has been based on a profound alteration of that psychology. Today the most successful units in the industry have predicated their entire operations on their mold shops, and have found that modern equipment, properly understood and used, has not only reduced costs but has paved the way to an enormous extension of uses and diversification of products.

Outstanding in modern mold making equipment are duplicating machines. At the very outset a distinction must be made between *duplication* and *repetition*. For these machines, while highly advantageous on repetitive work, do not depend upon it for their economies. They can operate from models and templates of easily worked materials, and by *duplicating* from masters of this type, can often *originate* molds of such size, complexity and accuracy as could hardly be produced at all by other methods.

There are two basic types of duplicating machines—the manual and the automatic. The manual machine (Fig. 8) is primarily a high-speed precision vertical miller. Its duplicating feature consists of a light aluminum alloy table for carrying model and work, mounted for very free horizontal and transverse movements. The operator moves the table in these directions by means of a universal lever held in his right hand. His left hand operates a lever to raise and lower the spindle, which is synchronized to a tracer spindle. A wide range of spindle speeds is available, providing a choice of cutters for all types of work within the range of the machine.

The spindle and tracer may be set for a uniform depth and the tracer point or style may be guided around an irregular outline. This profiling operation can be performed from master templates which are of heavy enough gage to withstand the amount of manual pressure necessary to feed the cutter into the cut. On the small work for which this machine is primarily adapted the neces-

(*Please turn to page 189*)

* This section was especially prepared for this issue by A. S. Keller, Pratt & Whitney, Div. Niles-Beaumont-Pond Co.



PLASTICS AVENUE

GENERAL ELECTRIC



ONE Plastics Avenue is a distinguished mark in the plastics industry. It is the address of the largest and most modern molding plant in the country and headquarters for the Plastics Department of the General Electric Company. It identifies the location of complete plastics facilities, brought together into a cohesive unit that results in a concentrated effort and increased efficiency . . . At One Plastics Avenue, Textolite is developed under rigid specifications to meet specific characteristics required by each application. Upon the quality of this material rests the quality of the finished molded or laminated part.

DEVELOPMENT



FROM General Electric's vast operations in four plants come myriad parts for most every important industry, for countless uses . . . Indispensable, in many instances, for the success of these parts is the designing and styling service which G-E offers to assure more salable merchandise and more economical manufacture . . . It is a service rendered by a competent staff of industrial designers who are thoroughly familiar with modern trends and styles and who are intimately acquainted with the characteristics of plastics, permitting them to render ably a new product design or make suggestions for design improvement.

DESIGNING AND STYLING



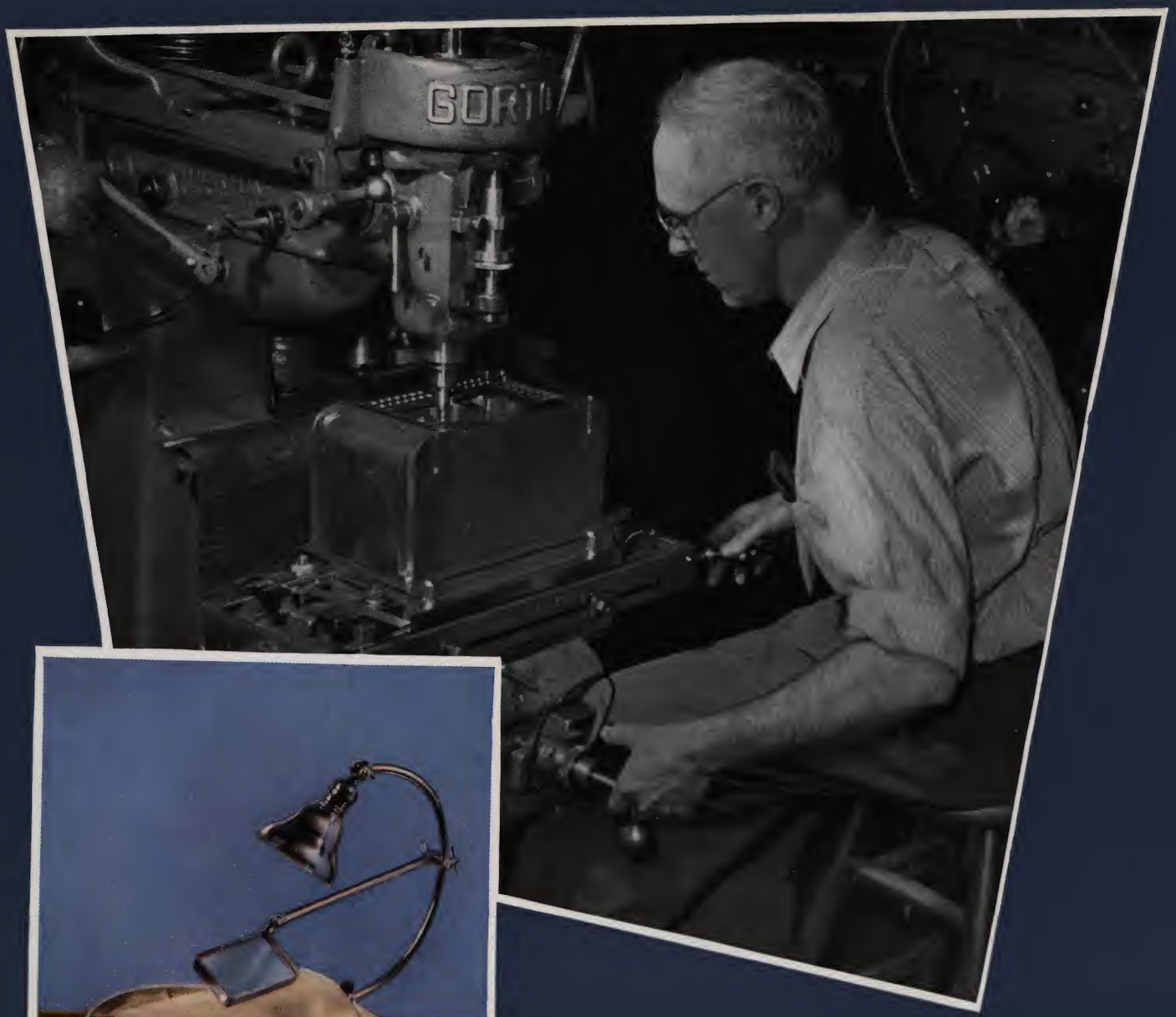
GUIDING and working side by side with the functional designers and stylists are the application engineers whose close contact with the customer and thorough knowledge of the function and mechanism of the customer's product make them of vital importance . . . Textolite parts are produced only when it is determined that this material will do a better or more economical job than other materials and it is the duty of G-E application engineers to give honest judgment as to whether these conditions are met. Their years of experience in working with plastics makes them extremely well fitted for this work.

APPLICATION ENGINEERING



CONTINUING these closely linked departmental activities, application engineers consult with product engineers as to the proper grade of Textolite and the actual design of the mold . . . Skilled in this highly technical business, G-E product engineers consider every molding problem—wall thickness, tolerances, shrinkage, projections, ribs, inserts, threads, etc.—in an earnest effort to design for beauty, utility and economy . . . In this section also, General Electric boasts an experienced personnel whose long background of actual moldmaking gives them an exact knowledge of what is required for practical molding.

PRODUCT ENGINEERING



FROM the designs of the product engineers, 150 G-E moldmakers, averaging 18 years' experience in the art, dextrously produce intricate molds to precise dimensions . . . In the efficient performance of this task, General Electric utilizes a completely equipped tool room with facilities for every required operation including drilling, profiling, hobbing, fitting and polishing . . . For further assurance of the best possible mold, G-E conducts a hardening room for proper annealing of the steel and makes a standard practice of electroplating molds of the parts for longer life and a smoother, more lustrous finish and ease of manufacture.

MOLDMAKING



IN its four plants, the Plastics Department operates more than 700 compression molding presses of an unusually wide variety — single ram presses of seven tons to multiple ram presses of 1500 tons . . . From them come an unlimited variety of Textolite parts—for radios, cameras, business machines etc.—that make for a simpler, more colorful and more comfortable living . . . Compression molded Textolite products range from parts so small that 100 fit into a teaspoon to some of the largest plastic pieces ever molded. All of them mean lower costs, simplified assemblies, finer appearance, beautiful colors or permanent finishes.

COMPRESSION MOLDING



ONE of the most important industrial consumers of Textolite products has long been the lighting fixture Industry for whom sundry reflectors, bowls and specialties are molded of Textolite . . . But during the past year the importance of this material in the lighting field has become even more outstanding . . . For with the advent of fluorescent lighting has come an increased demand for Textolite and the desirable translucence and light weight it lends to the lighting fixture . . . In both molded and laminated form also, the industry has found it particularly adaptable to fluorescent lamp holders and sockets.

LIGHTING LINE



IN injection molding plastics, General Electric's position in the industry is equally as advanced as in the other phases of its business . . . Fortified with a variety of sizes and types of presses, the Plastics Department is geared to produce thermoplastic parts to exact specification at a fast and uninterrupted production . . . Under close supervision of competent foremen, a typically trained G-E personnel turns out thousands upon thousands of Textolite packages for leading cosmetic manufacturers, shoe heels for women's shoes, radio knobs, refrigerator parts, gift items and novelties for country-wide consumption.

INJECTION MOLDING



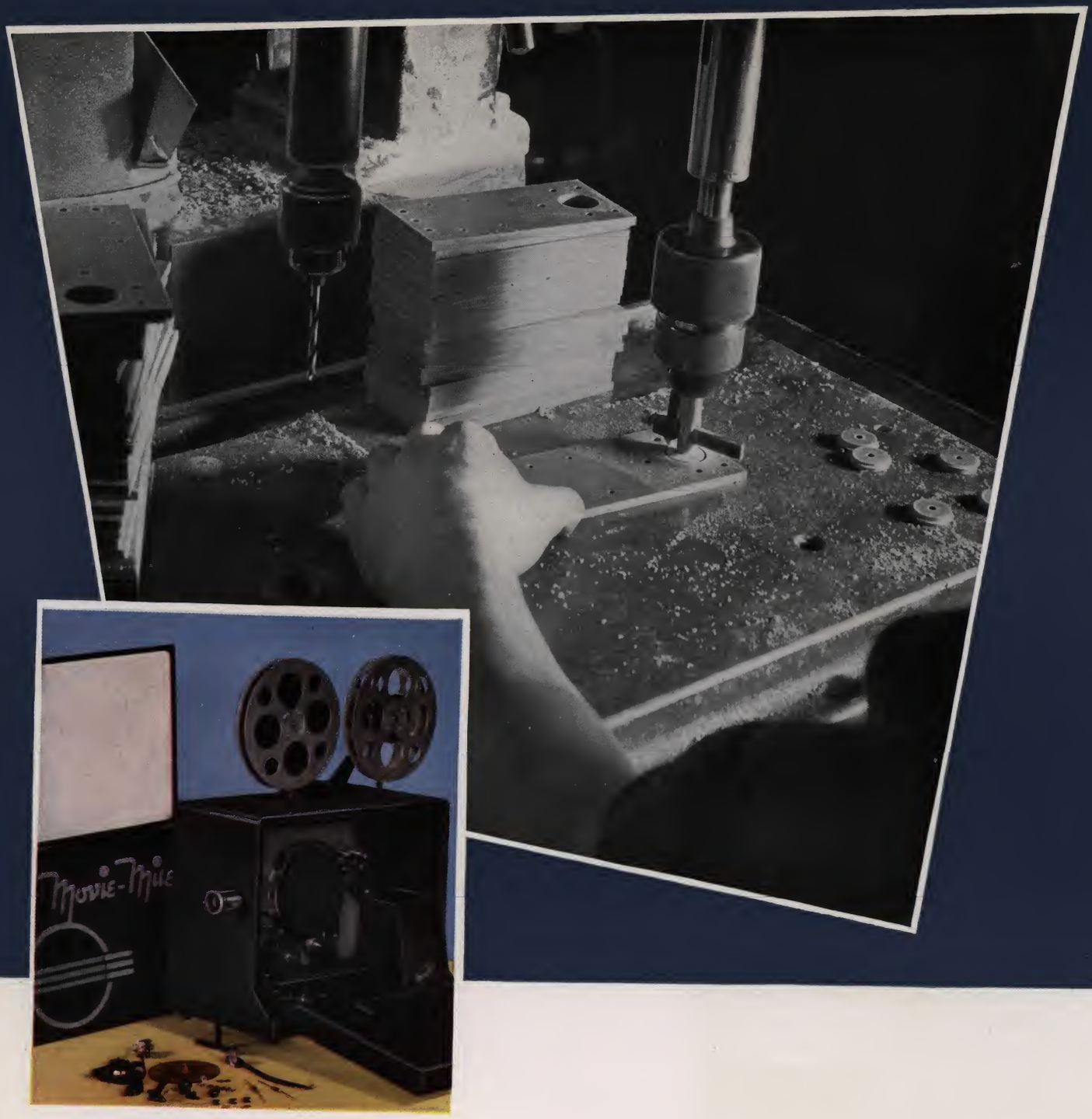
COMPLETING General Electric's well rounded activities in the molding of plastics is the manufacture of cold molded products of both the refractory and non-refractory types . . . Important because of its unusual resistance to heat and high arcs, Textolite, in cold molded form, finds many and varied uses for switches, heater connectors, arc chutes, small panel boards and similar products. Being a long established line with General Electric, the cold molding of these products to customer's satisfaction is assured by the Plastics Department's complete equipment and trained personnel at its Meriden, Connecticut plant.

COLD MOLDING



EQUALLY impressive as its molding activities are General Electric's accomplishments in the laminating of Textolite . . . This is plastics in a different form — produced when paper or cloth is impregnated with resins, or varnishes pressed in huge presses, and turned out in sheets, rods, and tubes... An extremely versatile material with exceptional properties, laminated Textolite serves countless purposes for a great many industries ... As an insulator, its applications are legion in the electrical manufacturing industry alone. As a mechanical application, it serves as roll-neck bearings, rayon spinning buckets, gears and fabricated parts.

INDUSTRIAL LAMINATING



FOR the fabrication of laminated Textolite, General Electric conducts an extensive operation at its Meriden, Conn. plant . . . Here this workable material is sawed, drilled, punched, threaded, bevelled, cut and tapped into almost any conceivable shape . . . Here, at high speed production, Textolite is produced in tremendous volume for a great many different industries . . . For the radio industry, fabricated laminated Textolite provides as many as 100 parts for a single set. In the electrical manufacturing, lighting fixture, automotive and many other industries, its wide range of uses is indicative of its value.

FABRICATING



THE third phase of General Electric's laminating operations for which the Plastics Department has established the most modern equipment in its Lynn plant is the manufacture of decorative laminated Textolite, translucent laminated Textolite and Parkwood Textolite . . . Materials that serve many purposes in architecture and interior design, their manufacture commands extreme care to assure a hard, smooth surface so necessary for their applications . . . Especially interesting is the Parkwood Textolite created by the combination of thin wood veneerings and plastics resins into beautifully finished panels.

DECORATIVE LAMINATING



THE final operation in the manufacture of molded Textolite products is performed in the finishing room where each part is drilled, tapped, filed, buffed, tumbled or otherwise finished in accordance with customer's specifications . . . It is the final step in the long line of manufacturing processes and is performed by skilled and competent persons whose dexterity permits quick adaptation to new and varied maneuvers in the technique . . . It is the finishing touch, as it were, to a product that commanded the individual responsibility of General Electric and the complete facilities of One Plastics Avenue.

FINISHING



CAREFUL inspection by eye or gage, ascertains that there are no flaws in the Textolite products as they flow from the finishing-room benches, while the use of modern shipping facilities adds to the speed with which the customer is served . . . This is all a part of the service that General Electric renders at One Plastics Avenue and its other plastics divisions. It is a service which any customer of plastics can easily obtain by the close commercial contact made available by the Textolite specialists in conveniently located cities or by communication with One Plastics Avenue, Pittsfield, Massachusetts.

INSPECTION

PLANTS:

Pittsfield, Massachusetts, 1 Plastics Avenue
West Lynn, Massachusetts, 920 Western Ave.
Meriden, Connecticut, 34 Cambridge Street
Fort Wayne, Indiana, 1635 Broadway

OFFICES:

920 Western Ave., West Lynn, Massachusetts
34 Cambridge Street, Meriden, Connecticut
1405 Locust Street, Philadelphia, Pennsylvania
570 Lexington Avenue, New York, New York
700 Antoinette Street, Detroit, Michigan
230 South Clark Street, Chicago, Illinois
4966 Woodland Avenue, Cleveland, Ohio
89 East Avenue, Rochester, New York
1635 Broadway, Fort Wayne, Indiana

PLASTICS DEPARTMENT
GENERAL ELECTRIC

PD-2093

9—Die, after being removed from heating oven, is lowered into oil bath for heat treatment. Temperatures are controlled through all stages of hardening. 10—Die at the instant of immersion in quenching bath



9



10

(*Continued from page 172*) sary feeding pressures are likely to be moderate, and templates can be similarly light.

When the depth of cut also varies, a three-dimensional master must be used. This is ordinarily an existing steel impression although in some cases artificial stone casts may sometimes be employed. These, however, are limited to jobs without sharp edges and corners which tend to be broken down by the pressure of the tracer point. Occasionally the sharper portions of the impression are embodied in molded phenolic inserts in the artificial stone master.

The operator of this machine need not have the skill and training required to produce the same jobs on conventional milling or die-sinking equipment, and by working from existing molds or other masters can ordinarily save a large percentage of the time required by such other methods.

The automatic duplicating machine is a horizontal milling machine, operated by electrically controlled power feeds in all three dimensions (Fig. 6). Master and work are mounted on a vertical angle plate fixture. Tracer and cutter are carried in fixed relationship on the head of the machine. The feeding motions are controlled by electrical contacts in the tracer, and the amount of pressure exerted on the tracer point is a constant, measured in ounces, and independent of the size of the job or depth of cut. Consequently there is said to be no practical limitation to the size of the work which may be produced, and these machines are built in a range of sizes capable of producing the largest molds which can be handled on modern presses. The delicacy of the electrical control permits the use of small cutters.

Like the manually operated duplicators, the automatic machine may be used to profile an irregular outline at a uniform depth. For this operation a thin sheet-metal template may be employed as master.

Three dimensional jobs may be produced from solid masters. The delicate electric control of this machine permits a wide choice of materials, wood, cement, matrix metals, plastic and artificial stone all being usable. Certain jobs having uniform cross sections can actually be produced without a solid master at all, but with two tracers, one operating on a depth template and the other on an outline template. The combination of motions produces the desired shape.

The power feeds of the machine permit it to take cuts up to the full capacity of large cutters, and on such work the cutter is protected from overload by an electrical feed control. The horizontal disposition of the spindle and the supply of a constant flood of coolant permit the ready removal of chips and continued cutter operation at maximum efficiency. Molds requiring the removal of hundreds of pounds of metal are thus handled with economy, it is claimed.

Some of the outstanding savings do not even show on the finished products. Many molds with sliding members and cam actions at numerous different angles can be duplicated. The job need be set up only once on the duplicator and the various cuts produced from templates or straight edges.

A three-spindle cutter head, whereby multiple jobs can be simultaneously produced from a single master or template and special attachments, such as the right and left fixture (Fig. 7), whereby a right-hand job can be produced from a left-hand master, are said to allow further economies.

There are a number of other duplicating machines and attachments besides these two types described. Hydraulic duplicating methods, particularly, have come to attention within the last few years. They differ from the machines described, however, largely in principles of construction. Their applications to mold work are all analogous to the operations which have already been described, and it is the task of the user to select the method or machine best suited to his requirements.

Heat treatment of plastic mold die and hob steels*

Plastic mold dies and hobs are generally made from hot-rolled bar stock in the smaller sizes while the larger are from forgings. After forging or rolling it is essential that the steel be thoroughly annealed so as to machine easily. This is usually preceded by the normalizing treatment which consists of heating the steel above the critical range to obtain uniform solution of the carbides and cooling rapidly in still air. In tool steel mills the steel is box annealed, brought up slowly to the annealing temperature, held until the charge is thoroughly heated through, and cooled slowly in the furnace. Usual an-

* This section was especially prepared for this issue by W. H. Wills, Allegheny Ludlum Steel Corp.

Table II. Approximate Composition of Mold and Hob Steels

Steel No.	Purpose	Analysis C	Mn	W	Cr	Mo	Ni	Annealed Brinell Hardness
1	Hobbing Die	.05	.15	..	...	...	..	100 max.
2	Hobbing Die	.10	.20	..	.60	...	1.25	125 max.
3	Cut & Hobbing Die	.15	.45	..	1.50	...	3.50	150 max.
4	Cut Die	.90	1.50	..	...	.30	..	196 max.
5	Cut Die	.65	.60	..	.65	.20	1.50	207 max.
6	Hobs	.90	1.50	...	...	.30	..	196 max.
7	Hobs	.45	.30	2.00	1.25	...	..	207 max.
8	Hobs	1.50	.40	..	12.00	.75	..	228 max.

Table III. Forging, Normalizing and Annealing of Mold and Hob Steels

Steel No.	Forging Temp. Initial	Forging Temp. Finish	Normalizing after Forging	Annealing Temp., Deg. F.	Rate of Heating	Time at Heat, Hr.	Cooling
1	1700–2000 ° F.	1400 ° F.	1600 ° F.	1525–1550	Slowly & uniformly	1–4	Slowly in furnace
2	1700–2000 ° F.	1500	1550	1475 1500	Slowly & uniformly	1–4	Slowly in furnace
3	1700–2000 ° F.	1500	1550	1450–1475	Slowly & uniformly	1–4	Slowly in furnace
4	1700–1900	1450	1550 ° F.	1375–1400	Slowly & uniformly	1–4	Slowly in furnace
5	1700–1900	1450	1550 ° F.	1400–1450	Slowly & uniformly	1–4	Slowly in furnace
6	1700–1900	1450	1550 °F.	1375 1400	Slowly & uniformly	1–4	Slowly in furnace
7	1800–2000	1500	1600	1450–1500	Slowly & uniformly	1–4	Slowly in furnace
8*	1900–2000	1600	Do not normalize	1600–1650	Slowly & uniformly	1–4	Slowly in furnace

* *Note:* Steel No. 8 after forging should be cooled slowly out of contact with air currents.

nealing cycle is about 18 to 24 hours or more, depending on the size of the charge. Shorter times may be used with smaller charges.

After hobbing or machining, dies must be heat treated to develop maximum wearing quality and strength. In this operation warpage and scaling of cavities should be held to a minimum. Carburizing steels come out of the pack with a reasonably clean surface. In heating for hardening a controlled atmosphere furnace or salt bath is desirable to avoid scaling. In some cases it may be helpful to pack in clean cast-iron chips or spent carbonizing compound to preserve the surface of the cavities. The heating should be slow and uniform preferably to the low limit of the hardening range. The quenching bath should be of ample volume. Tempering should follow promptly after quenching.

Tool steel for hobs should be handled much like die steels as regards preserving the surface although they are tempered at a lower temperature for maximum hardness and compressive strength.

Tables II, III and IV show type analyses and recommended heating ranges for forging, normalizing, annealing, hardening and tempering the principal types of steel for plastic mold dies and hobs:

Table IV. Heat Treatment of Mold and Hob Steels

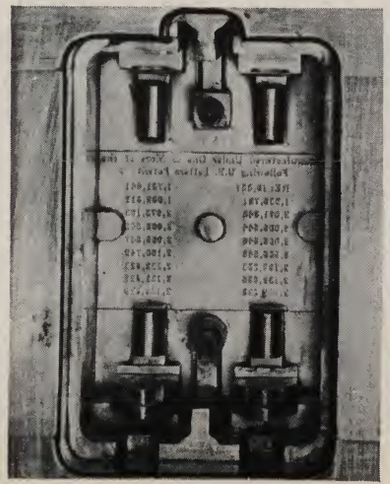
Steel No.		Carburizing Deg. F.	Rate of Heating for Hardening	Hardening Temp., Deg. F.	Quenching Medium	Tempering Temp., Deg. F.
1o	Mold Steels	1650–1700	1½ hr. per in.	1450–1475	Brine or water	300–400
2o		1650–1700	1½ hr. per in.	1450–1475	Brine or water	300–400
3o		1650–1700	1½ hr. per in.	1400–1425	Oil	300–400
4o		Not carburized	1½ hr. per	1400–1450	Oil	400–500
5o		Not carburized	1½ hr. per in.	1475–1525	Oil	400–500
6o	Hob Steels	Not carburized	1½ hr. per in.	1400–1450	Oil	325–400
7o		Not carburized	Pack harden	1650–1700	Oil	325–400
8o		Not carburized	1½ hr. per in.	1800–1850	Air	400–1000

Ekko molds and dies*

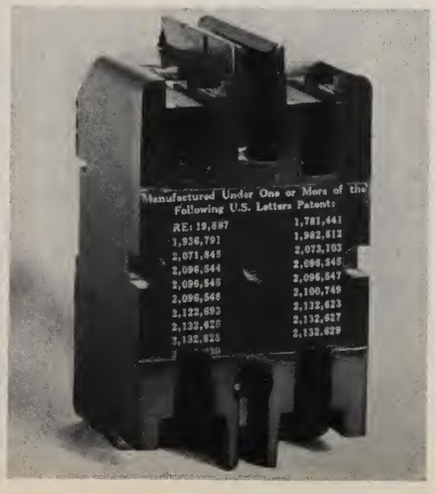
The *Ekko* Process for the preparation of molds and dies by electroforming with iron was announced over a year ago by the United States Rubber Co. and has since found wide application in a variety of industries including plastics. Suitable for either thermoplastic or thermosetting materials, Ekko molds contribute to the plastics

* This section was especially prepared for this issue by E. H. Wallace, U. S. Rubber Co.

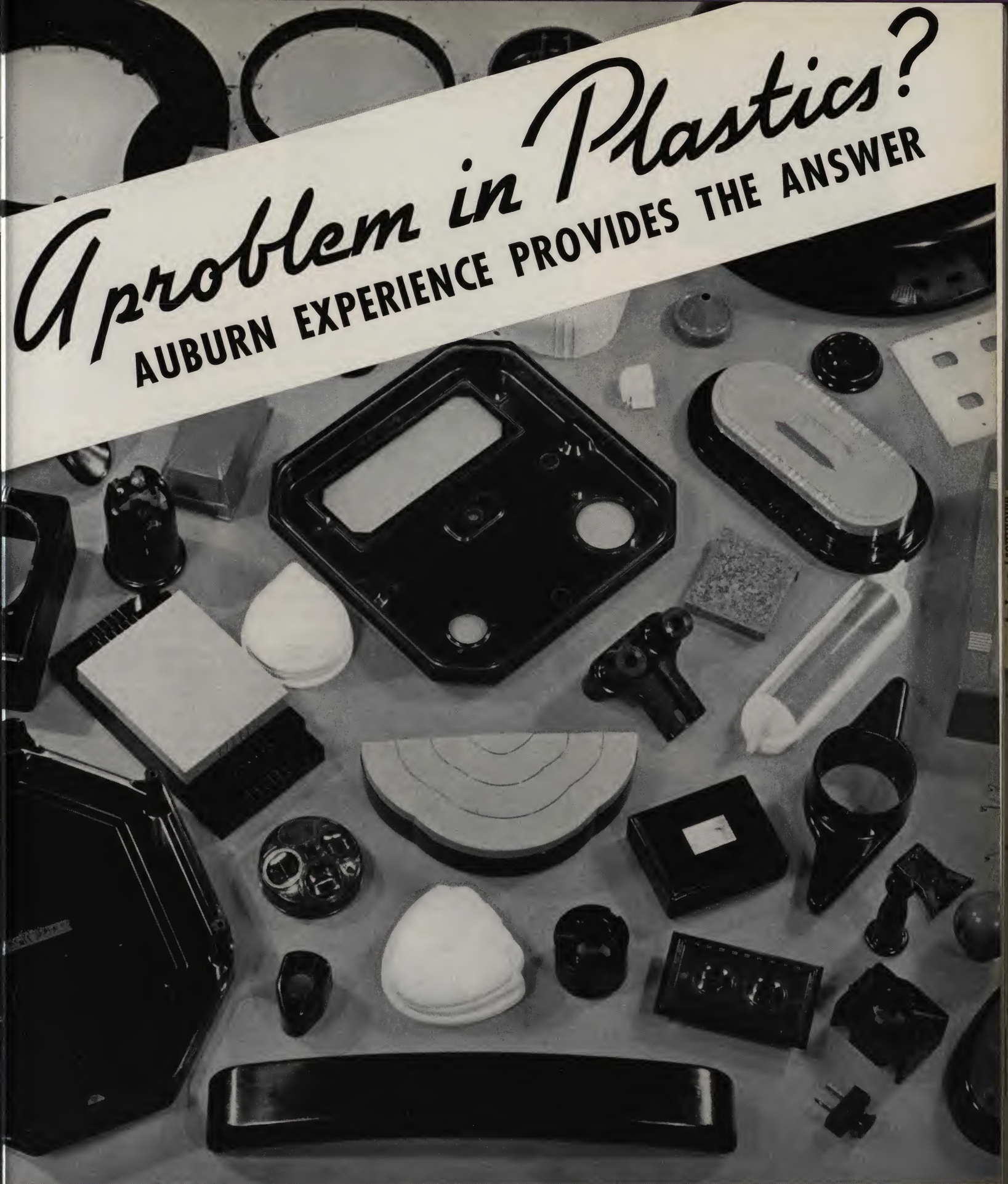
11



12



11—Intricate mold with letters and numerals electroplated by the Ekko process. 12—Details are clearly reproduced in the phenolic switch-housing molded by Square D Co. There is no pitting nor discernible unevenness

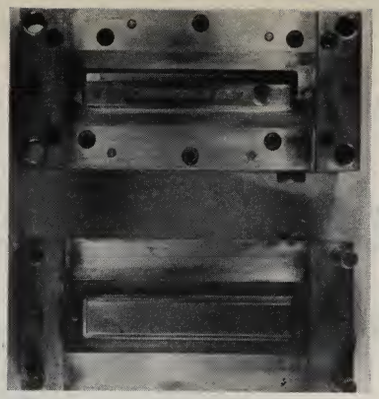


ESTABLISHED 1876

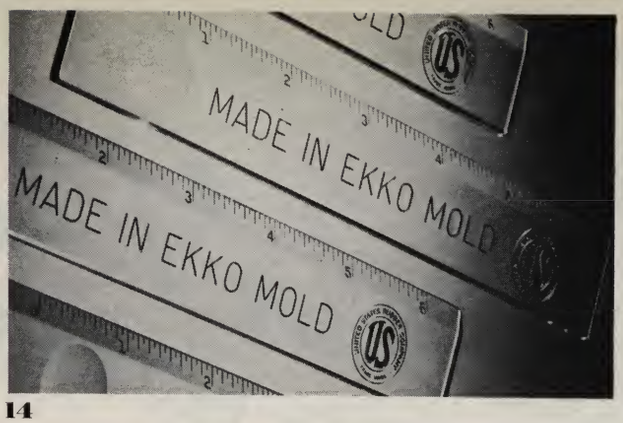
MOLDED PLASTICS DIVISION OF

AUBURN BUTTON WORKS, Inc.

AUBURN, N. Y.—New York, Chicago, Detroit, Cleveland, Rochester, Boston



13



14

13—Male and female parts of mold electroplated by Ekko process. 14—Compression molded methyl methacrylate scale with a magnifying disk molded-in by American Insulator Corporation

industry in a triple capacity. To the customer, the process offers the opportunity for a more ornate product ordinarily ruled out by mold costs. To the designer, it offers unusual effects such as reproduction of natural wood grain or leather surfaces in plastics. To the die maker, it offers "difficult to engrave or hob" cavities which require no polishing.

In the process, a $^3/_8$ in. to $^1/_2$ in. deposit of iron is electroplated on a suitable pattern which is later separated from the electroformed shell, leaving a mold cavity. This cavity when suitably backed yields a mold which has reproduced faithfully the dimensions and surface finish of the pattern. Created at temperatures below 200 deg. F. no problems of shrinkage arise. In one test on the reproducibility of detail, a diffraction grating having 7400 microscopic lines to the inch was used as the pattern and the sixth generation electroform faithfully carried the design.

The iron deposited is practically pure, usually containing no silicon, .001 percent phosphorus, .004 percent manganese, .006 percent copper and .007 percent carbon. Ekko cavities as formed are adequate for service no more severe than rubber molding; for plastics the pure iron is transformed to carbon-steel by carburizing.

Materials suitable for Ekko pattern materials, listed in the order of preference, are: metal, rubber, plaster of Paris, plastics, wood, glass, leather or cloth. Steel, brass or Cerrobase** are the best metals while zinc, aluminum, magnesium or their alloys cannot be used. Rubber is ideal when duplicating an existing cavity as any number of patterns can be cheaply prepared by molding a special non-shrinking stock to the desired shape. Plaster of Paris requires extra time for processing and gives a fair mold finish. Certain phenolics and cast methacrylates are the only plastic materials found to date which will withstand the temperature and chemical nature of the electroforming bath. A molded plastic object cannot be used as a pattern to duplicate exactly the original cavity because of its inherent shrinkage. Wood patterns must consist of one piece; glued sections are not suitable. Glass, under some conditions, is ideal as an extremely high polish can be reproduced in the cavity.

Cavities, depending on the usage, are backed by machining, cast or sprayed iron and special alloys. The machined type of backing is shown in Fig. 11 where the back of the cavity was shaped to an even contour and dropped into a steel block hollowed out to receive it. Non-symmetrical cavities require optional backing methods and the application of sprayed iron has been found most suitable for plastic molds. Pure iron or alloy steel is applied to the carburized Ekko cavity and the outside machined for insertion in a chase before the quenching operation.

** Cerrobase—a non-shrinking alloy which can be cast at 250 deg. F., made by the Cerro De Pasco Copper Corp.

Forming molds by spraying metal

This technique for making molds quickly was recently developed* and is being tested in production runs, according to the company. It consists of spraying metal on or around a form or matrix and then removing the sprayed metal shell which with suitable backing serves as the cavity of a mold. It is reported to be especially adaptable where a great many dies of identical character are required for big runs; for applications where very close tolerances are not essential and where finely engraved lines and extremely detailed patterns are to be reproduced.

The molds can be made by spraying metal, such as hard steel or stainless steel, bronze or any other metal which can be obtained in wire form, onto a master of the object to be molded. The metal spray gun used to do the work is essentially a small portable foundry. Three gases—acetylene, oxygen and compressed air—are used in its operation. Part of the compressed air is used to drive a small air turbine which feeds the metal in wire form through the gun. The wire is melted as it passes through the acetylene flame and then blown out in very finely divided molten particles and deposited upon the model which is being sprayed.

The model may be made of wood or plaster, which are much easier to engrave than steel, or it can be made of plastics, stone, metal or almost any other material with a smooth hard surface against which the metal can be sprayed.

The sprayed cavities require no heat treating, it is said, and the hardness of the mold depends upon the metal sprayed. Some of these molds are being run now and have been reported to stand up exceptionally well in test performance. The test runs have been sufficiently rigid to determine the practicability of using molding pressures sufficiently high for the successful molding of thermosetting plastics.

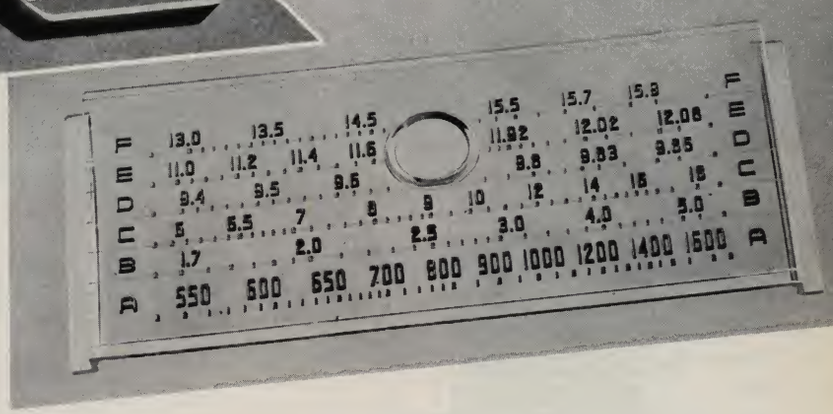
Backing up the shell to give it stability to withstand plastic molding operations is done by either of two methods—casting or spraying. In either case, the mold is finished by turning in a lathe to get a perfect surface to contact the chase, and the base is either ground or

* Metallizing Engineering Co., in MODERN PLASTICS, June 1940, page 36.

ERIE *Custom Molded Plastics*



"THREE DIMENSIONAL" PLASTICS *



ERIE "Three Dimensional" Plastics opens a world of new possibilities for obtaining unusual color effects and three dimensional appearance of lettering and decorative designs in molded name plates, knobs, dials, panels, handles, etc. The large radio bezel, illustrated above, has decorative lines of gold that stand out in relief from a gray-brown background. The edges of the numerals in the transparent dial at the right are outlined with a sharp, glareless light that is piped through the Lucite plastics from illumination applied on the outside edges. As the characters are molded and colored from the rear, they are not subject to surface wear. If you are using metal inserts or filled, engraved lettering, characters or decorative lines in your molded pieces, you'll be amazed how much more attractive and easy to read Erie "Three Dimensional" Plastics can make these inscriptions.

Erie offers a complete custom molding service beginning with design sketches and engineering cooperation on every phase of development work. All dies are designed and their construction is supervised by Erie engineering and production experts. Modern injection-molding presses and finishing equipment for stamping, buffing, spray painting, cementing, etc., assure workmanship of the highest quality. These facilities of the oldest exclusive injection molder in this country are fully described in the Erie Plastics Catalog, just off the press.



Left: Heavy wall sections, undercuts, and intricate coring operations that usually "kill" many difficult molding jobs, are successfully coped with by Erie plastic engineers.

Write for your copy →



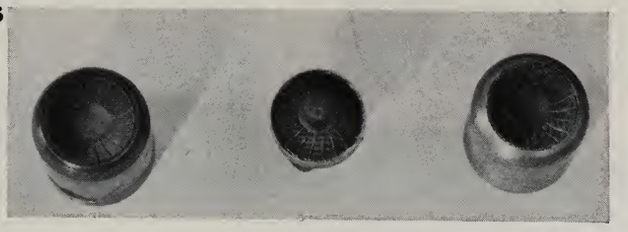
*LICENSED UNDER THE CARDINAL CORP. PROCESS

Plastics Division

ERIE RESISTOR CORPORATION, ERIE, PA.



15



16

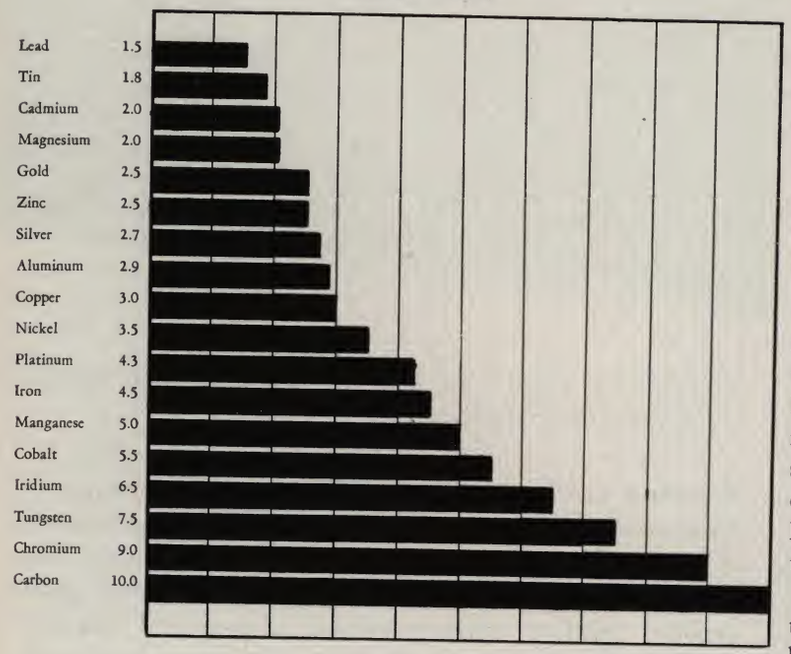
15—By spraying melted steel wire against a model through this gun a mold cavity of the impression is built up as the metal cools. 16—Small button embossing die (center) made by spraying onto the original (left). About 5 minutes were required for spraying steel cavity (right). (Photo, courtesy Metallizing Engineering Co., Inc.)

machined to fit. It is said that it is possible to get accurate centering by this method. Metal for backing can be sprayed on almost indefinitely, sometimes up to three or more inches, we are told. In other instances it is more practical to take the sprayed metal shell out of the lathe, flux it, and cast metal around it for backing. The choice of method depends upon what sort of backing is required for the completed mold.

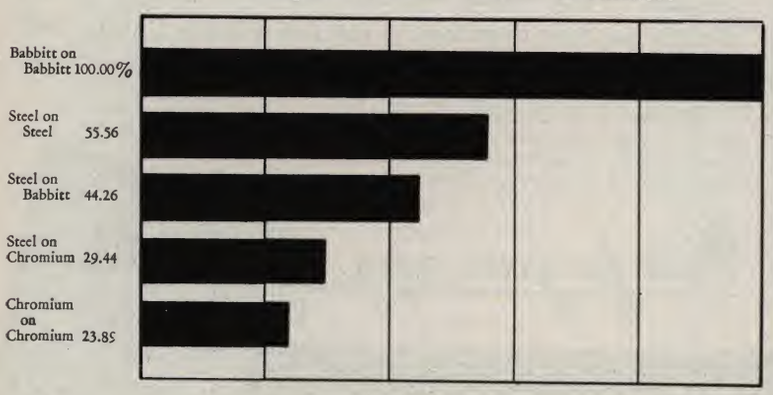
The length of time required for forming molds depends almost entirely upon the size and complication of the die to be sprayed. But usually the time required is exceedingly short when compared with machine operations unless the mold is very simple in form.

The process is covered by patents and patents pending and is available to the industry on a licensing basis.

Comparative Hardness of Metals (Moh's Scale)



Comparative Static Friction of Surfaces



Chromium plating of molds*

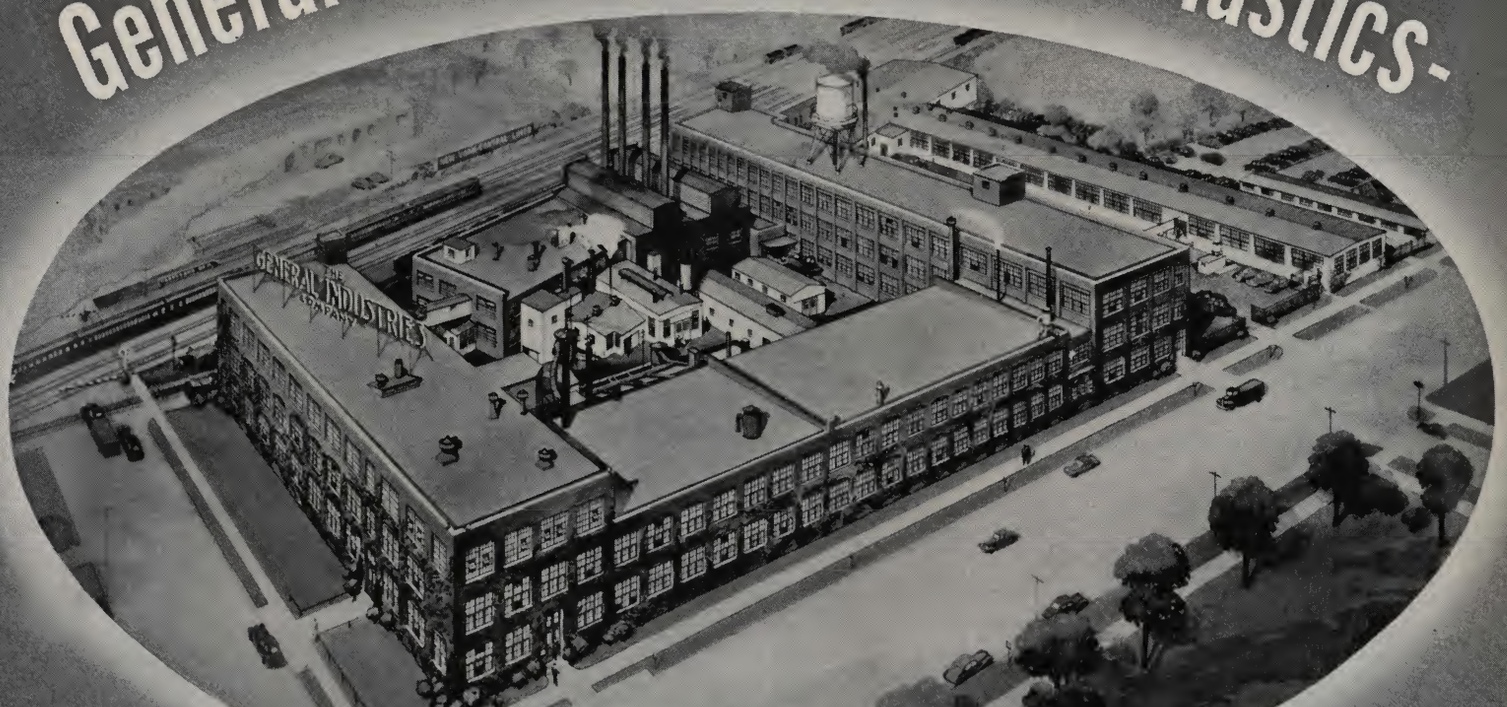
Ideal performance objectives of plastic molds involve many qualities which may often be made available by the suitable application of industrial chromium plating. Probably the most important basic requirements include resistance to abrasive wear, protection against corrosion, smooth and slippery mold surfaces and maintained precision. Chromium plating from the industrial viewpoint has over a period of years been developed to such an extent as to enhance all of these various properties.

Chromium is one of the hardest known metals; virtually twice as hard as ordinary steel and exceeded only by comparatively rare substances such as corundum, boron and diamond. The proper application of chromium plate by electrodeposition increases the hardness of suitably prepared base metals and provides a surface which is highly resistant to wear and abrasion. As a substitute for expensive hardening treatment, chromium permits the further economy of cheaper base metals.

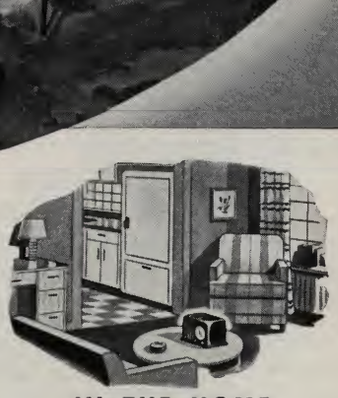
Chromium is virtually non-corrosive, but it is seriously attacked by hydrochloric acid and to a lesser extent by sulphuric acid. It is impervious to urea compounds and practically all other acids and alkalis. The corrosive protection which it imparts to underlying metals is complete when properly applied for that purpose, under which conditions it will not crack, chip,

* This article was especially prepared for this issue by D. H. Bissell, Chromium Corp. of America.

General Industries Molded Plastics-



Everywhere . . .



IN THE HOME–



IN INDUSTRY–

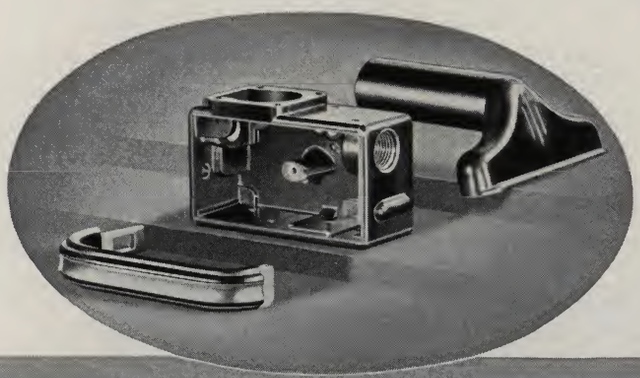


IN TRANSPORTATION



IN SPORTS

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★ ★ ★

You incur no obligation by inviting us to figure on your next job. Just send us blue prints and indicate your monthly requirements.

THE GENERAL INDUSTRIES COMPANY

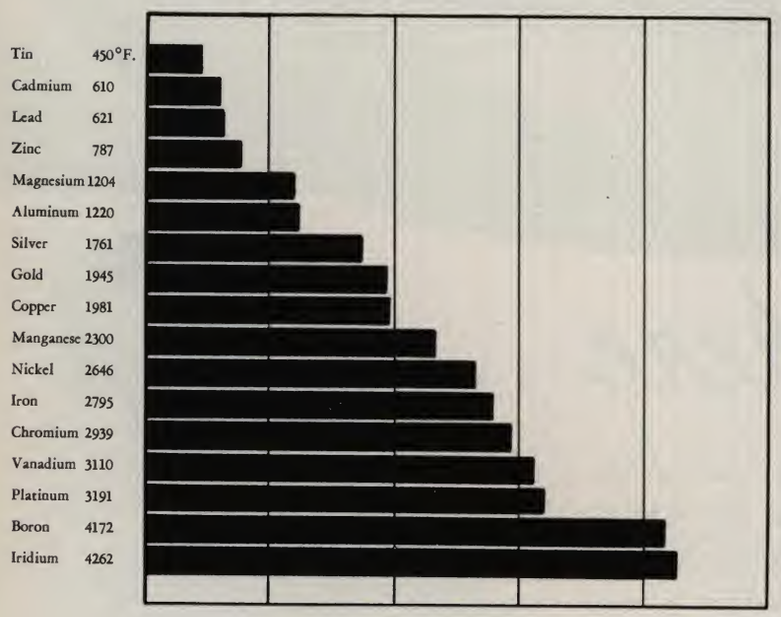
MOLDED PLASTICS DIVISION • OLIVE AND TAYLOR STREETS, ELYRIA, OHIO

scale, peel, pit or blister. The importance of correct specifications for adequate protection must be recognized if the desired result is to be permanently attained.

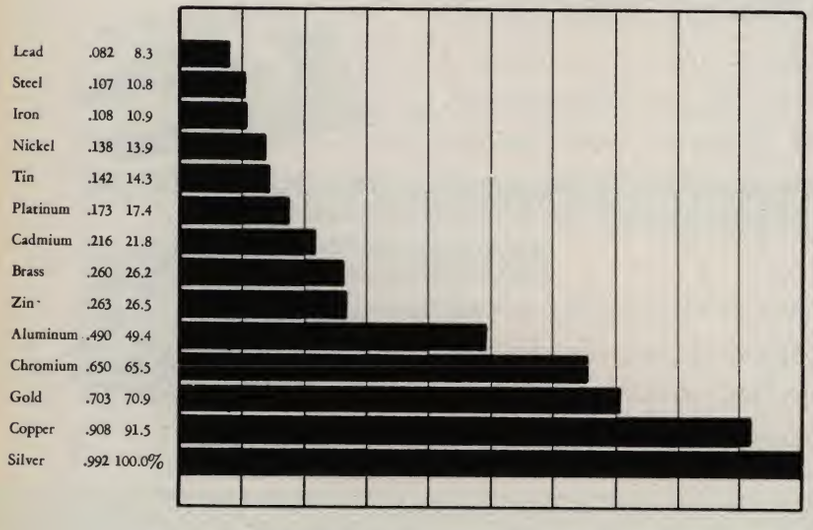
The extreme smoothness of chromium-plated surfaces is especially valuable in forming and molding operations wherever quick and easy release of finished products is desired. The improved finish of mold surfaces may be transmitted to the molded product, resulting in a correspondingly finer surface in the molded article. Plated surfaces may be easily and quickly cleaned; there is no excuse for accumulated surface dirt.

It must be recognized that chromium plating of molds is by no means an unfailing remedy for unsatisfactory base metal. Physical base metal characteristics are of the utmost importance. The use of clean, highly finished steel adds materially to the satisfactory performance of chromium-plated molds. Unplated surfaces, to give best results, should be prepared with extreme care, for even the most minute surface defects are accentuated by chromium plate. Although small pits and other defects will be covered by the plating, they will not necessarily be bridged or filled, since electrodeposited chromium faithfully follows the contour of the surface upon which it is plated.

Melting Points of Metal



Heat Conductivity of Metals



Chromium melts at 2939 deg F., resists oxidation to 1150 deg. F. and physical breakdown to 2500 deg. F. Its heat conductivity is good, likewise its resistance to the effect of drastic temperature changes such as the intermittent use of steam and cold water. Care must be taken, however, to prevent too wide a variation of heat expansion coefficients of the base metal. This may be avoided by consulting qualified plating engineers.

Through the use of special conforming anodes it is possible to chromium plate the most intricate cavities. It is likewise possible to *stop-off* the plating of designated areas by the use of lacquer. It is frequently desirable to lap, grind or polish after the electroplate has been deposited. In preparing steel molds for chromium plating, proper allowance should be made for the thickness of the chromium to be deposited, which will vary in accordance with the individual characteristics of the parts themselves and the purpose for which they are used.

After plated molds have been in use for a considerable time the chromium may in some cases be stripped and the molds replated, thus materially prolonging the useful life. Care must be taken, however, to avoid any undue wear of the underlying metal before this is attempted.

Wherever extreme accuracy of size is essential, chromium plating has been found helpful by reason of its extreme hardness and long-wearing qualities. The corrosive action of chemical compounds cannot cause pitting, and here again the finish of the product is maintained without the necessity for frequently changing molds. Improvement in visual quality of finished products is often noticeable. Low coefficient of friction helps to reduce spoilage due to more easy release of the molding.

Only careful engineering analysis can properly determine the most suitable and economical plating specifications. Perhaps the most important factors in obtaining satisfactory performance of chromium-plated equipment are the experience, skill and technical knowledge of the plating organization. This is particularly true in industrial chromium plating which demands a much higher degree of skill and experience than the ordinary decorative plating, with which it is often confused. In some instances, performance failures of plated parts have resulted in blanket condemnation by users who failed to realize or appreciate the importance of using a reputable and competent chromium plating service.

Chromium plating remains relatively a new art; important improvements in plating processes have been made during the last decade and new developments are constantly appearing. The basic characteristics of chromium, which are now more than ever conveniently available through the medium of electrodeposition, are becoming increasingly helpful in industrial usage.

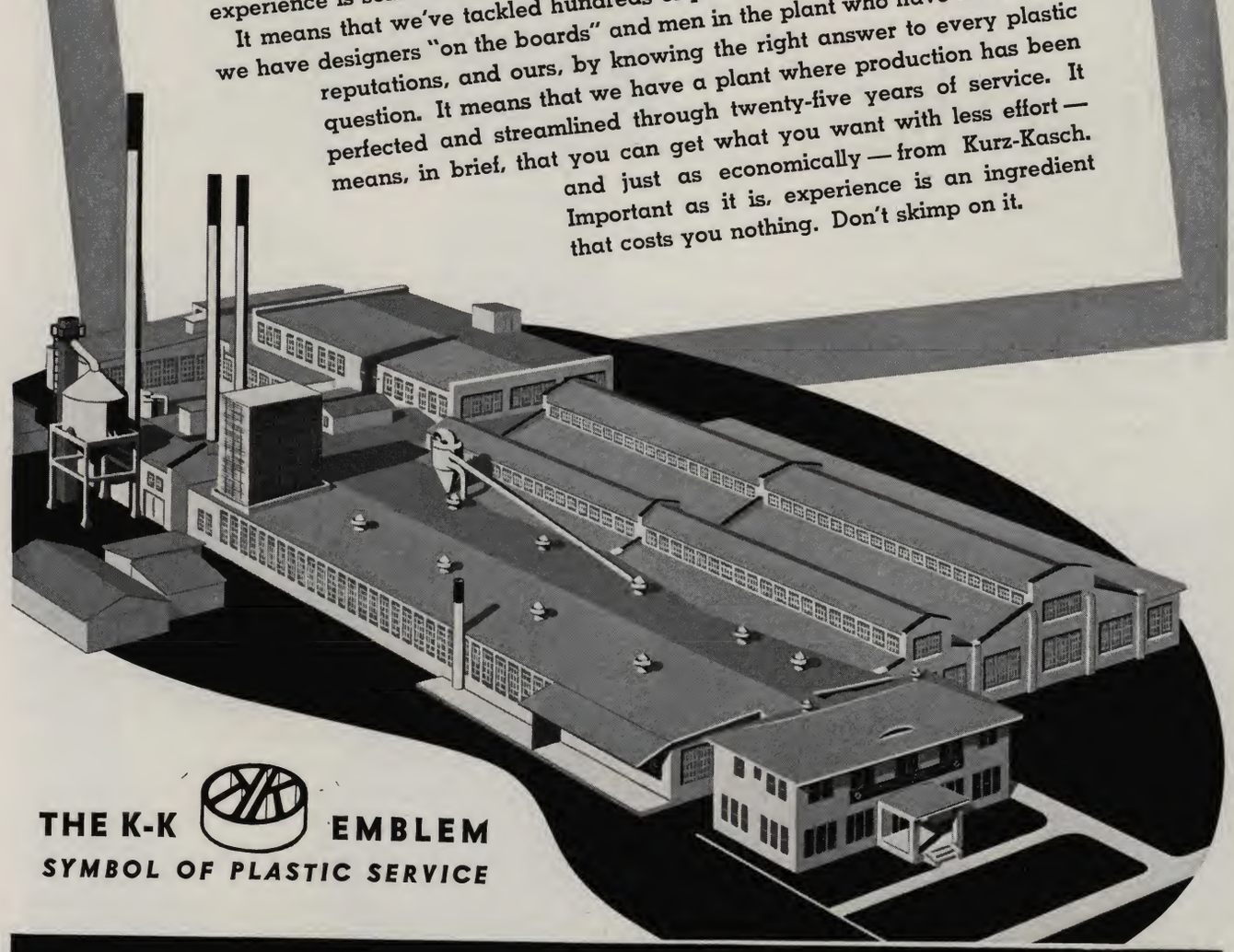
When you're planning a PLASTIC... DON'T SKIMP on EXPERIENCE!

● Kurz-Kasch was specializing in plastic molding when plastics wore short pants — back in 1916 when plastics were supposed to be a passing fancy.

You could, if you wanted, call us pioneers, though that seems a little stodgy for a firm that is maintaining its leadership today just as energetically as it ever did. Whatever you call it, however, this much is clear — we couldn't be in the plastic molding business as long as we have without knowing more than our share of the answers.

From your point of view — as a user of plastic parts — our accumulated experience is something to consider.

It means that we've tackled hundreds of problems like yours. It means that we have designers "on the boards" and men in the plant who have made their reputations, and ours, by knowing the right answer to every plastic question. It means that we have a plant where production has been perfected and streamlined through twenty-five years of service. It means, in brief, that you can get what you want with less effort — and just as economically — from Kurz-Kasch. Important as it is, experience is an ingredient that costs you nothing. Don't skimp on it.



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ONE OF THE LARGEST EXCLUSIVE MOLDING PLANTS IN AMERICA



Preforming condenses the molding compounds so that molds are more easily and quickly filled, insures an accurate charge to each cavity and prevents waste of compound. Difficult shapes closely approximating the molded parts, shown beside each preform at left, are from Chicago Molded Products Corporation.

Preforming

PREFORMING for the plastics industry consists of compressing the various types of molding powders into "pills" or tablets. This is accomplished with special machines constructed for this purpose. These machines are of two general types, namely, the single stroke machine and the rotary. Essentially both of these types of machines work on the same principle in that the molding powder is placed in a hopper and a predetermined quantity or weight is automatically fed to the die or dies and sufficient pressure is applied to the charge of molding powder in the die to compress these many granular particles into a tablet. The rotary machine is more generally used for the more simple type preforms having a capacity of 250 to 400 pieces per minute. The single stroke machine is more generally used for large or more intricate types of preforms and it has a capacity of 50 to 150 per minute. These machines are adjustable so that various weight preforms of the same general shape can be made on the same dies; they are also adjustable for hardness of preform.

The older method of handling was to weigh charges of molding powder for each cavity in small cups and charge each cavity by hand. The inefficiency of this method and inability to turn out the many millions of pieces molded today is self evident. From this stage the industry advanced to using loading boards which are still used in some shops. These consist of boards with holes for each mold cavity of a definite size and shape. There is a shuttle fastened to the bottom which is closed when the board is being loaded and tripped to drop the molding powder in the cavities when the board is placed over the mold. For loading, the molding powder is poured on the board and the excess scraped off. Most loading boards of this type are not adjustable to compensate for the variation in the apparent density of various molding powders which results in considerable waste due to short-weight pieces or excessive flash. Even though the board is made to contain the correct charge for one particular powder it is often over-charged due to the bench or board being jarred which results in settling an excess of powder in the loading cavities.

Preforms are also usually handled with a similar type loading board. The preforms are poured on the loading board and then it is shaken in order to have the preforms settle in the cavities on the board. In order to avoid spillage it is advisable to have a raised rim on the front and sides of such loading boards.

The preforming of molding powder is essential to the efficient operation of molding plants for the following reasons:

1. *Accuracy of weight.* To keep waste at a minimum it is essential to have a definite quantity of molding powder for each molded piece and preforming is the only satisfactory method of obtaining this uniform weight. This weight is usually 10 percent over the actual weight of the finished molded piece. The extra weight is to insure that all pieces are completely filled because short pieces are rejected, which means a loss of


Stock Valve Handles
Diemolding Corporation is one of the largest manufacturers of valve handles in the world. Molds are immediately available for the production of handles in large quantities, for all types of valves, in all shapes and sizes, with or without metal inserts.
We have also earned an enviable reputation as a successful custom molder of all types of plastics for a wide variety of uses. Our long years in the molding business are backed with a fine, modern molding plant. Our skilled engineers and craftsmen, many of them with us for years, are ready to give experienced consideration to your plastics molding problems.
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NEW YORK

the powder and labor involved. Theoretically it should be possible to operate with no flash but in practice it is found that the material may start flashing on one side of a piece before the other side is filled which results in a short piece. Some shops run with as low as 5 percent flash which is generally due to the cavities in the molds being more uniform in size than they are in the average shop. On the other hand, excessive over-weight results in a large unnecessary flash loss and it may even result in heavy fins or the flash sticking to the land of the mold. This flash can be removed but it costs money.

2. *Space saving.* Many flash molds today are so shallow they will not hold the necessary volume of loose powder which has a bulk $2^1/_2$ times that of the final molded piece, while preforms are roughly only $1^1/_8$ times the bulk of the finished piece. Preforms also aid in getting a concentration of material in one portion of the mold which at times is especially desirable when molding with long inserts as an excessive flow of powder tends to bend or dislodge them. In other cases it may be difficult to fill a certain section of a molded piece and often a concentration of material at this point is an aid in getting completely filled pieces.

3. *Aid in preventing precure.* When charging loose powder into a mold cavity some of the fine powder adheres to the mold surface and often before pressure is applied some of these little particles have been heated sufficiently to precure which results in a poor finish on the final molded piece. This is less likely to occur when preforms are used since all the cavities of the mold can be loaded faster and the mold closed sooner, and there are no small particles to adhere to the surface of the mold.

4. *Aid in distribution of mottles.* When mottles are used for making molded specimens usually a more uniform distribution of the components is obtained when preforms are used. This results usually in a better-looking molded piece with more uniform mottling.

5. *Convenient handling for preheating.* Although not all molders practice preheating, those who do, find it simplified when preforms are used as the preforms are conveniently transferred to and from ovens or steam platens used for the preheating operation. Furthermore the preheating enables molders to obtain a faster cycle in the mold and usually results in better finish and less warpage trouble—this is particularly true of colored molding powders.

6. *Aid in reducing contamination.* It quite often happens that black material may be running on both sides of a press where a white is being molded. If loose powder is used the drift of the black powder necessarily contaminates the lighter color and it often results in excessive rejects. The use of preforms materially reduces the floating dust in a shop, making it possible to mold white and black in adjoining presses.

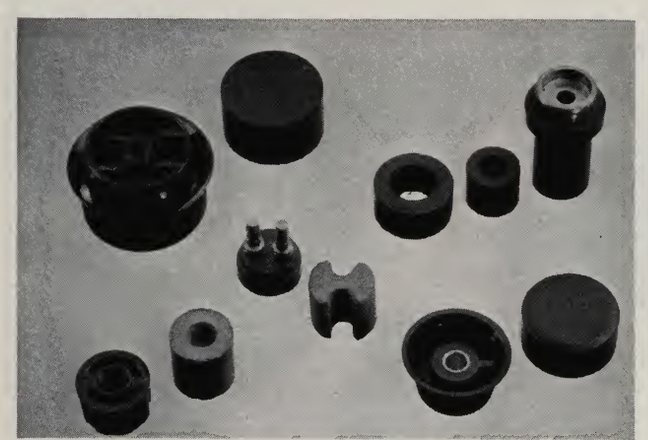
7. *Cleanliness and housekeeping.* The use of preforms is a material aid in keeping a shop in an orderly and presentable appearance. Molding powder is necessarily dusty and dirty if it is not kept confined and there is no way to confine it. When preforming equipment is used it is practicable to install dust-collecting apparatus in the preform room thus minimizing the dust factor and keeping it away from the presses and operators.

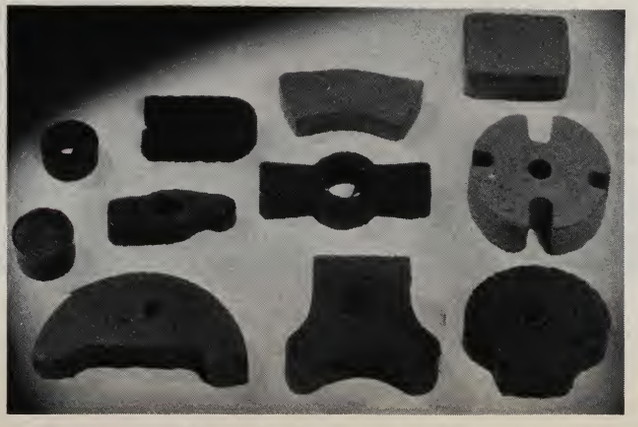
Types of preforms vary over a wide range, chiefly depending upon the type of mold and the type of piece being molded. In general it is desirable to approximate the shape of the piece being molded since this aids in proper distribution of the molding powder in the mold cavity. The varied shapes it is possible to make, at times, turn a particularly troublesome molding job into one that is simple and profitable.

Fibrous materials are often troublesome in preforming, the trouble usually being in obtaining uniform weights. This is largely due to the poor pourability of the material. An aid in overcoming this would be to suspend a rod from the top of the hopper to the toe of the shoe on a single stroke machine. The rod must necessarily be bent in order to pass it through the neck of the hopper and to the toe of the shoe. The shuttling of the shoe moves the rod which tends to keep the material feeding uniformly. Running the machine at a slow rate is also an aid in obtaining uniform weights.

The modern trend in the industry is to preform and mold in a continuous automatic cycle. This is beneficial for the industry since it means lower costs and will tend to enlarge the market for molded plastics. However, where such equipment is not yet available preforming is the most practical method of handling molding powder since it pays dividends in reduced waste and higher quality of molded pieces.

Typical preforms of various shapes below are from Auburn Button Works, Inc., and Northern Industrial Chemical Co. Some shapes indicate eventual use but most preforms are made into tablets, rings or balls





SCULPTURED Beauty

"Maidenhood" by George Grey Barnard, Brookgreen Gardens, S. C.



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Compression molding

COMPRESSION molding is the term usually applied to open mold construction—where the compressing plunger forms one of the finished surfaces of the molded piece. It is largely used for thermosetting compounds, but is sometimes used for thermoplastic materials. Methods other than compression include injection molding, and continuous extrusion molding.

There is a special form of compression molding which deserves brief mention. It is known as *double molding*. In this process a preliminary top plunger is used to partially form the molded piece with suitable recesses to receive inserts or core pins. As soon as this plunger is pressed to its final position it is immediately withdrawn before the molding material is cured—the inserts or core pins are then placed in position—additional molding material is added—and then a second or final mold plunger presses the whole mass together until full cure is effected. This second plunger is of different shape than the preliminary plunger, and forms the final shape of the top of the molded piece. This process is not recommended unless the designer of the piece to be molded has a working knowledge of the various special problems and difficulties incident to its successful use.

Before deciding which of the above mentioned methods of molding should be employed to form a piece, consideration should be given to the following points:

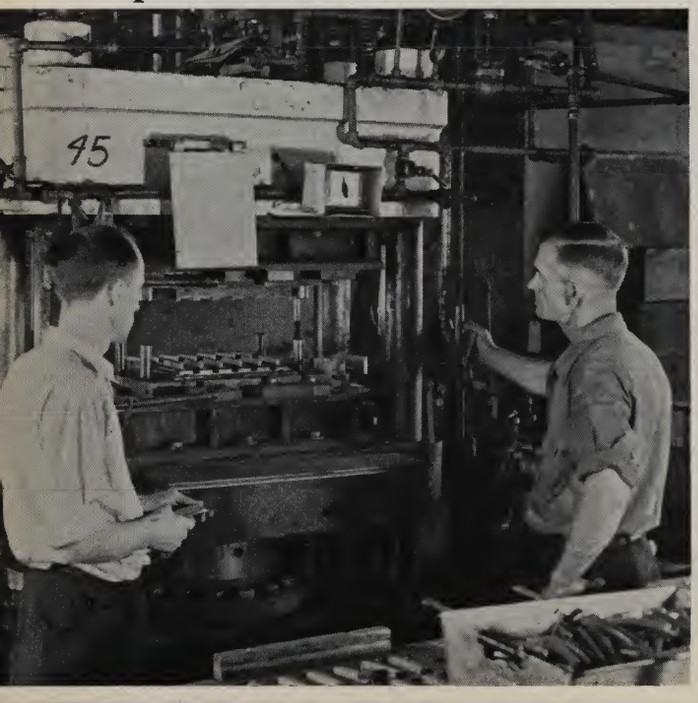
1. Ejection of piece from the mold.
2. Shape and position of inserts.
3. Size and position of small bore holes.
4. Consideration for the life of, and the upkeep expense on tools.
5. Loading of mold.
6. Proper heating of all parts of mold.
7. Pressure required to completely fill cavity.
8. Elimination of gases if urea compounds are the materials being molded.
9. Upward force of molding material flowing under high pressure.
10. Wedging action of long tapered plungers.

Following are a few comments on the above points, but no attempt will be made to discuss them in detail.

1. Ejection. It may strike the layman as being almost axiomatic that a mold would be designed so the piece could be ejected. He might also assume that it was an attempt to be humorous that such an obvious requirement of a molding method or mold should be given prime consideration. It does not by any means follow that a mold which will form an intricate piece will also eject the piece without distortion, even assuming it will eject at all. This question of ejection is one of prime importance, and although it determines mold design, it should—and frequently does—determine what method of molding will be adopted to produce pieces to the best possible advantage. *(Please turn to next page)*

1—Typical compression molding operation with multiple cavity mold at Diemolding Corp. Preforming to weight and dimension requirements speeds up loading. 2—Battery of French Oil Mill Machinery Co. presses installed at Ford Motor Co. in production on automotive parts. These presses are timed for semi-automatic cycles. The large scale production necessitates infrequent mold changing

1



2





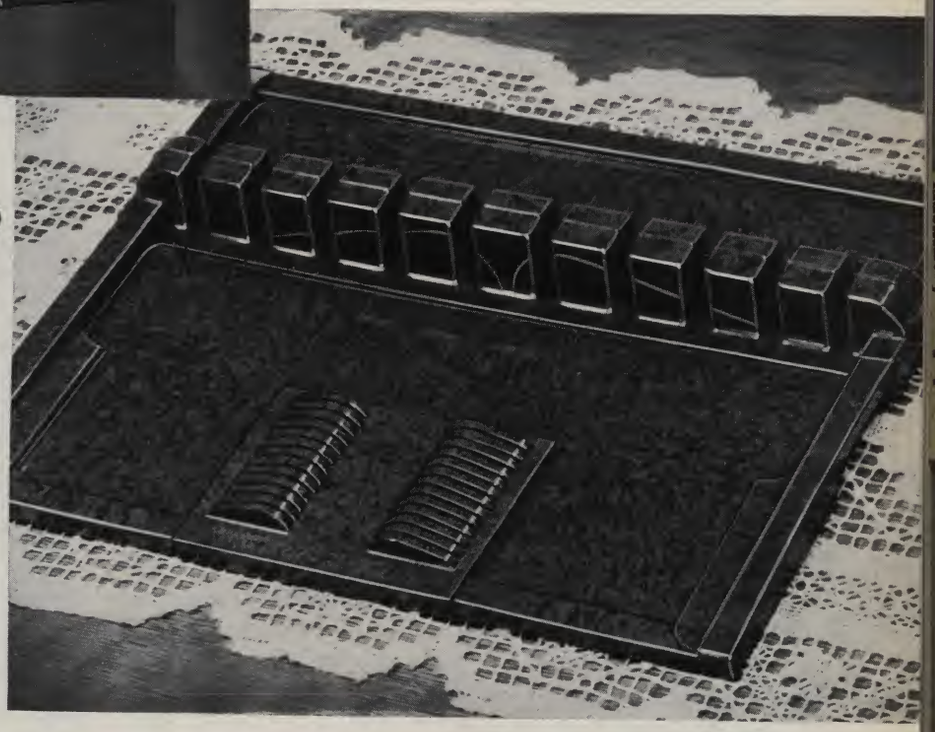
LARGE

or small

BRILLIANT COLOR
BLACK OR WHITE
PLAIN OR MOTTLED

All

PRECISION MOLDED



Northern

These two large pieces are shown because they are large — *the radio cabinet, 10 inches high, 14 inches wide and 6½ inches deep, is typical of many large mouldings with reinforcing thicknesses, slots, holes, threaded screw seats, etc. — all combined for good appearance and easy assembly with chassis, etc.* An entirely different moulding is — *the silverware tray — 15 inches long, 12 inches wide with raised bosses standing up 1½ inches from the flat area.* Across the bottom of this page we show a number of smaller mouldings — some mechanical parts requiring precision fitting, some with metal inserts, some in colors — all typical of our production and indicative of the scope of our facilities. If you have a problem for which moulded plastics may provide the answer, our engineering department is ready to give full cooperation.

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3

3—In large molding plants the installation and removal of dies is facilitated through the use of overhead cranes. This also expedites the transportation of dies and other equipment from one section to another. (Photo, courtesy General Electric Co.)

2. *Shape and position of inserts.* There can be such an endless variety of shapes and positions of inserts that no set of rules can be made to fit all cases.

The determination of method of molding and the mold design itself must be predicated on a careful consideration of this point. A background of experience is essential to make these determinations if the shape or placement of inserts is intricate.

A molding procedure may be perfect to produce a certain piece—with one very small exception. The exception might be the impossibility of preventing insert carrier pin breakage for just one insert, or it might be a slight bending or shifting of one of the inserts. In cases of this sort the mold is a complete loss and failure unless supplementary means are adopted to circumvent the error.

3. *Size and position of small bore holes.* Much the same sort of examination and planning for inserts is also required to determine how to mold a piece with long small bore holes. In ordinary compression molding the plastic material is frequently moving and flowing under 3000 to 4000 lbs. per sq. in. pressure during the molding operation. This pressure times the projected area of unsupported core pin is a force with which to be reckoned. It should be given major consideration in determining whether the piece should be molded by compression or by other means.

If compression molding is decided upon, then the mold should be designed in such a way that the hazard of broken or bent core pins is reduced to a minimum. There are various ways to meet situations of this sort, e.g.: try to get customer to modify the design; introduce cores in the mold which will take the direct thrust of pressure from the moving material, and deflect the current from the core pin in question; mold as deep as possible from two opposite sides, and drill the rest after molding; provide the hole with a deep and large diameter counterbore (if customer will allow it); make the molding material flow in a direction parallel to the core pin axis.

4. *Consideration for life of, and upkeep expense of tools.* If large productions of any piece are contemplated—then this question of tool life and upkeep expense should be given careful attention. It can and should be one of the main points to be considered in determining what method of molding to adopt.

To the molder with a background of wide experience, who has been confronted with the problem of restoring worn-out tools for making millions more of a piece after the first million, this expression has a real significance. Errors in judgment can be packed with dynamite in the form of tool upkeep expense.

The intelligent purchasing agent will give this point consideration in deciding whether to place the business with the low or high tool bidder.

5. *Loading of mold.* In compression molding the charge of molding material is placed directly in the mold cavity. The charge may be in loose powder form, or in preforms of convenient size and shape. The lower cavity of a mold is seldom large enough to accommodate the charge and therefore additional "filling room" for the cavity must be provided.

There are various ways of providing this extra space; but the details belong more to the subject *Mold design* than to compression molding. It may be of interest, however, to merely list some of these ways.

1. Extension of maximum area of mold cavity to form deep "well" for filling. (Positive type mold.)
2. Extend a wall of steel upward around the outside edge of a positive land to form a "well." The positive land might be from $1/16$ in. to $1/2$ in. wide depending upon size and shape of cavity. (Positive land type mold.)
3. Disappearing type loading jacket.
4. Floating jacket type mold, which allows lower plunger to move downward, providing deeper filling well.
5. Removable loading jacket.
6. Stripper plate die—with stripper plate designed for "loading" as well as "stripping" purposes.

Preforming the molding material prior to loading the mold is a simple process of pressing the loose powder cold in a preforming mold. This is usually done in an automatic tablet machine. Both the single punch, and rotary (multiple punch) type of tablet machines are used for this purpose.

Materials of large bulk factor and "fluffy" type materials are difficult to preform because they will not feed through the hopper of automatic tablet machines. They can be tabletted by individual charge-weighing, and hand-loading the preform mold. This is a slow and expensive procedure.

Preheating of molding material is essential for best results in compression molding. Rotary-type heaters, and oven tray-type heaters are both successfully used for powder materials. Hot plates and oven trays are used for preheating preforms or tablets. In long steady runs

TOPS *in the automotive field!*



NORTON MOLDINGS

Norton has been a consistent leader in automotive molding, winning award after award in Modern Plastics Competitions for car accessories. Cadillac, Packard, Buick, Hudson—the leaders come to Norton for moldings that are accurate and beautiful.

The dials and the lens represent work done for Packard, Buick, Lincoln-Zephyr and Hudson in methacrylate resins. But Norton's fine work is not restricted to this one field, but covers all important uses of plastics. Norton molds exquisite boxes, fine dials, handles, housings and a variety of other objects of *all* plastics for Kelvinator, Revere Brass, Hygrade Sylvania and other leaders of industry.

Norton's finishes are famous through the industry for achieving just the effect desired. Norton's plant and skilled engineers are at your service in the solution of your molding problem. Both injection and compression methods are available.

NORTON LABORATORIES, Inc.

LOCKPORT **NEW YORK**

of molded parts it is frequently possible to work out a relation between preheating time, and curing time which results in a high production rate per cavity per hour.

6. Proper heating of all parts of mold. This is another important point to consider in any mold designed for compression molding. The two fundamental requirements for transforming molding powder into molded parts are heat and pressure.

Because heat is a fundamental requirement it follows that careful attention should be given this question of heat transfer to all parts of the mold. Almost any mold will become hot all over if given time enough, but the well planned molding method and mold will provide adequate and rapid heat to all parts of the mold.

Deep molds and molds with large diameter cores often present troublesome heating problems. These problems can be overcome in various ways but must be planned for in the original mold design. Electric cartridge heaters can be used in remote locations to supplement steam heating. In some cases induction heating may be used for cores. Rapid heat transfer can be made to pay dividends through fast production rate and low molding costs.

Different mediums are used to transfer heat from the source to the molding surfaces of compression molds, e. g.: steam, electricity, circulating hot water under pressure, circulating hot oil, and gas flame. Each medium has its proponents.

7. *Pressure.* This is the second of the two fundamental requirements. It is relatively simple to provide enough pressure per cavity, but some pieces of unusual design present filling problems which pressure alone will not solve. In certain shapes, air traps are formed which no amount of pressure within reason will fill with molding material. Enough pressure to collapse steel plungers is not sufficient in such cases.

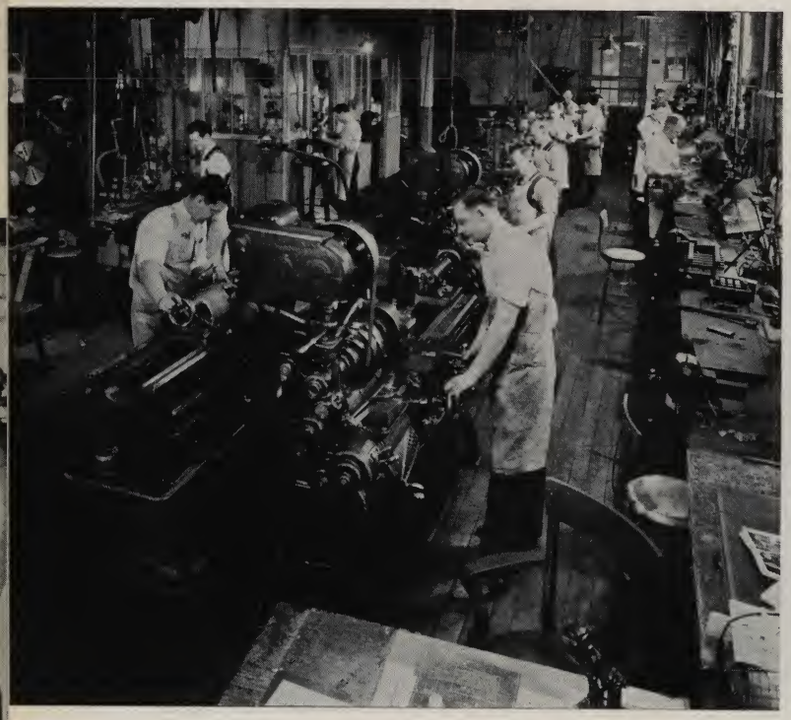
If such air traps are recognized when molds are being designed it is generally easy to vent them and the trouble is eliminated before it starts.

For the general run of phenolic and urea type molding materials the pressure required is from 2500 to 4000 lbs. per sq. in. Deep draw pieces may figure higher than this if only the projected area of the largest section is divided into the total pressure per cavity. This would not be a sound basis of figuring because no consideration is given the "area of draw" in such a calculation. A method frequently employed to determine the minimum pressure required per mold cavity is to use the formula: (Projected area by 2500) + (area of draw by 1000).

Pressure on the molding material during the molding operation can play all sorts of pranks on the mold designer in cases where extreme accuracy is required. Excessive molding pressure used in one way can reduce shrinkage—used in another it can increase shrinkage beyond normal. Varying pressure in the mold cavity resulting from unusual molded shapes has a marked effect on shrinkage. In one extreme case two sides of a square opening in a clock case shrank a normal amount, whereas the other two sides shrank 50 percent more than normal. Pressure was the explanation of this inconsistent shrinkage. *(Please turn to next page)*

4—Lathe equipment of the style depicted in this shop is almost universally used. Machining required on many molds is done to completion on these units. 5—This group of vertical Gortons is one assurance of tool excellence. In addition to doing precision work these machines are designed for reducing the number of operations to a minimum

4



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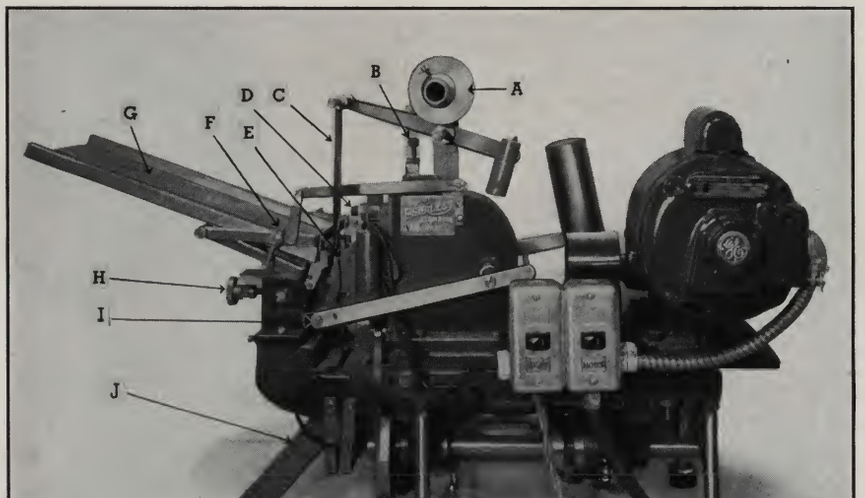


PEERLESS ROLL LEAF AUTOMATIC PRESSES LATEST DEVELOPMENT IN PLASTIC MARKING

UNION CITY, N. J. To its extensive line of stamping presses available for marking and decorating plastic products, PEERLESS ROLL LEAF CO., INC., 4515 New York Avenue, Union City, N. J., has added two automatic roll leaf hot stamping presses. One is designed for marking cylindrical plastic items, the other for flat pieces.

Automatic Rotary Press

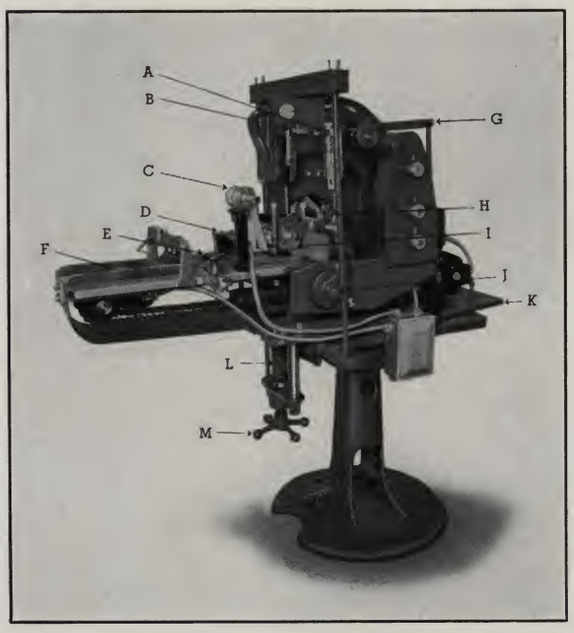
The Peerless Model No. 2 Automatic Rotary Roll Leaf Hot Stamping Press shown at the right was developed originally for marking miniature baseball bats made from plastic or wood barrels. It can be adapted for the marking of any cylindrical plastic item with a diameter not greater than one-half inch. It is particularly suitable for marking pen and pencil barrels, plastic rods and tubing, etc., within its size range. Fully automatic, it requires but little attention from the operator. Articles are fed into a loading chute from which they are fed into proper position facing a flat stamping die over which a roll of leaf passes. With each operation of the press the article is revolved against the heated die. The design and the leaf are transferred to the surface of the plastic or wood article. The stamped article is then ejected into a chute. The press utilizes brass type or dies mounted in a box chase. The stamping speed can be designed for fixed speeds of 25 to 50 impressions per minute. It is very compact in size, occupying a space only 18″ × 36″ × 24″ high. It weighs approximately 150 lbs. The press can be equipped with a 110 volt or 220 volt A.C. or D.C. motor. The heating range is 100°F. to 350°F. controlled by a Fenwall heat control.



Peerless Model No. 2 Automatic Rotary Roll Leaf Hot Stamping Press. A—Roll leaf holder. B—Roll leaf adjusting screw. C—Web of roll leaf. D—Automatic heat control. E—Chase. F—Trip door. G—Loading chute. H—Pressure adjusting screw. I—Tension bar. J—Waste leaf showing impressions.

Automatic Press for Flat Articles

For stamping flat articles such as combs, small rulers, etc., Peerless developed its Model HB-2 Automatic Roll Leaf Hot Stamping Press. A feature of this press is that the stamping head operates only when an article comes into position to be stamped. This eliminates waste of leaf. All the operator has to do is keep the press supplied with roll leaf and place the articles to be stamped on the chain feed. It has a variable speed feature with an average of about 70 impressions per minute. Belt-driven from a 1/3-h. p. motor. This press can be quickly changed over from one job to another within its size limitations.



Peerless Model HB-2 Automatic Roll Leaf Hot Stamping Press. A—Leaf adjuster. B—Counter. C—Roll leaf holder. D—Trip finger adjuster. E—Slide guide adjusting screw. F—Chain lug. G—Clutch trip rod. H—Roll feed attachment. I—Chase. J—Chain adjusting screw. K—Motor adjusting table. L—Table support spring. M—Table support screw.

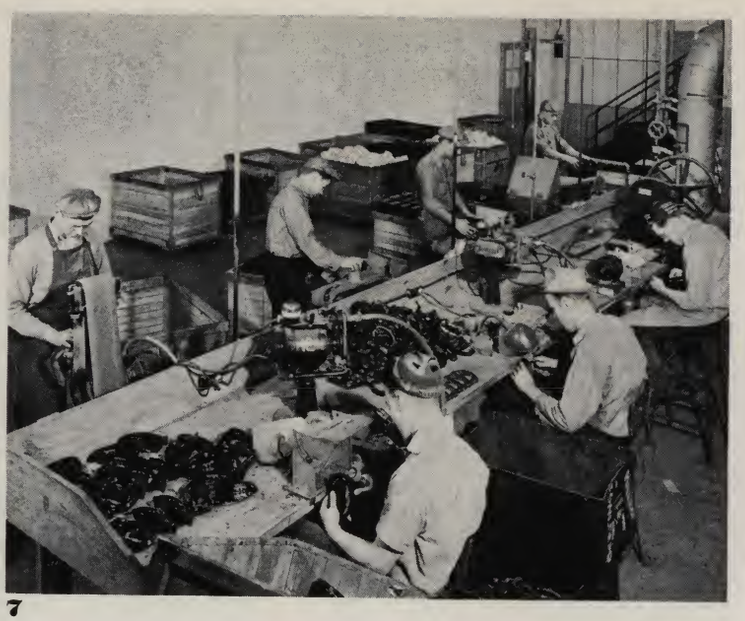
Complete Line of Presses

These new automatic presses are but two of an extensive line of Peerless hot stamping presses designed for marking and decorating plastic items with roll leaf. The Peerless line includes everything from small hand type presses up to large automatic presses with special feeds to handle large production items economically. While Peerless presses are available in standard models, they can be adapted to specific requirements.

Impressions made on plastic surfaces by the Peerless process are comparable to those produced by molding and engraving operations. They do not rub or wear off easily. The Peerless line of hot stamping leaf includes gold, silver, and colors. If you would like to see how the Peerless process of marking plastics can be applied to products you use or manufacture, send samples to be marked and returned. We shall be glad, also, to send further details and a sample of plastic marked with roll leaf. Write to PEERLESS ROLL LEAF COMPANY, INC., 4515 New York Avenue, Union City, New Jersey. Branches located in Cambridge, Mass., and Chicago.



6



7

6—Multiple-drive presses equipped with reamers or taps as required accelerate the speed of finishing molded parts. Jigs serve as guides where needed. 7—Final sanding, finishing and inspection complete the molded article. Inspection such as this, routine practice in most plants, insures well maintained quality

8. Elimination of gases. In compression molding this question is generally not given much consideration unless pieces are to be molded from urea compounds. In case urea compounds are to be molded the mold should be designed so that it can be "puffed," or opened slightly to eliminate gases, without too much danger of tearing the partially molded piece, or disarranging inserts.

Trapped air or gases generated during the molding process sometimes interfere with filling the mold cavity in remote corners. Venting such places or allowing an excess of molding material to run through these corners to an overflow pocket will overcome such difficulties.

9. Upward force of molding material during flow. When molding material in a mold cavity is being displaced by a plunger during compression molding, the upward thrust on the side walls of the cavity is a force to be reckoned with. If the side walls are integral with the bottom of the cavity there is no problem. If the side walls are formed by a jacket separate from the top and bottom plungers, then this upward force must be given consideration.

Unless this force is offset, the jacket may rise sufficiently to let the molding material out the "back door" before the cavity can be filled. This condition can be met by making a deep enough positive engagement between the jacket and lower plunger. There are also other methods of accomplishing this result.

In split molds, where the split part is held together by means of side hydraulic cylinders, it is easy to overlook this question of upward pressure. If overlooked it is almost sure to rear its ugly head after the mold is made, and plague the designer. Here again it is easy to meet the condition and make provision for it by interlocking keys or some other suitable means if the need for it is recognized at the time the mold is originally designed.

10. Wedging action of long tapered plungers. If pieces with deep holes having a long gradual taper are to be produced by compression molding this wedging action should be studied. Consider, for instance, a deep lily shaped vase having facets on the outside, a flared-out circular base and a gradually tapered deep hole for holding the water and flowers. Such an outside shape requires that the mold be split. The split halves must be held together by means of a solid jacket, or supplementary side hydraulic ram.

In a case of this sort it will be found that an enormous force will be required to keep the split halves together. The reason is that when the mold is nearly closed the wedging action of the tapered plunger against the nearly hard molding material creates an almost irresistible bursting force against the split halves. Unless a sufficient holding-together force is available, the designer would do well to consider methods other than compression molding to produce pieces of this shape.

To the layman who sees compression molding done for the first time, it looks very simple. He sees the mold cavity filled with powder or tablets, the mold closed under heat and pressure, the mold opened, and out comes the molded piece, finished except removing a few fins. What he doesn't see is the background of experience that is built into the mold. There is an expression "You can't play every instrument in the band," and this thought should be brought home to the man who decides to design and build his own mold to save money, unless he has had previous experience in designing molds for compression molding.

INDEX THIS Trade Mark



This symbol identifies the products of the Universal Plastics Corporation . . . an organization of skilled molders who have been responsible for a large number of revolutionary innovations in molding technique and application — of which the above is a typical example. We are equipped to work on all plastic materials, on injection and compression molding presses of all types.

UNIVERSAL PLASTICS CORPORATION

Custom Molders

Factory: 235 Jersey Avenue, New Brunswick, N. J.

New York Office: 500 Fifth Avenue



1—This large group of injection machines at the Ford plant are capable of handling substantial production. They readily meet the demands of a large automobile assembly line. Dies grouped in the center are placed for ready availability when required

1

Injection molding

SINCE the first injection molding machine was imported into the United States in 1934, much progress has been made in this molding art. We refer to it as an art because although there are probably somewhat over 1000 machines in operation in the United States today, there are still many problems to be worked out both from an equipment and method standpoint. In other words, injection molding has not yet been reduced to a science and until this time is reached, results must be secured by more or less cut and try methods subject to the judgment of the individual designers or molders. This applies to both the thermoplastic and the thermosetting types of materials.

Injection molding of thermoplastic materials

Like many other fabricating operations, it is necessary to control the forces of nature involved and inasmuch as there are principally five variables to be considered the different combinations of these variables are practically unlimited. The five variables referred to are as follows:

1—Materials feed.
2—Temperature of materials.
3—Injection pressure.
4—Clamp pressure.
5—Mold temperatures.

Materials feed

1. The quantity of materials fed into the heating cylinder is important despite the automatic equipment available to date. For example, when injecting one ounce of material per shot, the most ideal situation would be to feed one ounce of material into the heating cylinder for each movement of the injection piston. This insures a continuous uniform flow of material through the heating cylinder and enables more rapid cycles without the danger of overheating or burning the material. In other words, such an accurate and uniform condition permits higher temperatures on the material and more rapid plasticizing than an irregular or spasmodic feed. The faster the material is forced through the heating tunnel, the higher the temperature must be in the cylinder.

In changing materials, the normal procedure is to blow out the hopper and remove all visible traces of materials that have been running, then fill the hopper with the new material forcing the old plasticized material out through the nozzle until such time as the new material comes through clear and clean. All of this mixed material must be discarded because of the incompatibility of the various thermoplastics. An extremely small percentage, even as small as one-tenth of one percent butyrate, would cause an extremely high rejection of finished acetate, styrene, methacrylate or vinyl molded parts. One of the most important and most expensive difficulties in an injection molding plant is to avoid contamination of one material with another. Their similarity in appearance makes this difficult. (*Please turn to next page*)



Use ATTLEBORO MOLDINGS

(that's what the airwaves are saying)

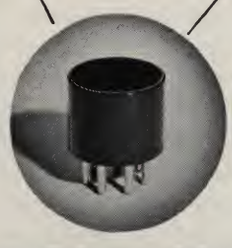


Follow the leaders in American Radio—Emerson, Philco, Zenith, Pilot and Fada use Attleboro molded housings for their radios.

Attleboro has long been known as a leader in molding precision housings of large size, and in large quantities. Our extensive plant facilities make the production of huge numbers of fine cabinets a routine task.

Although we turn out quality moldings for some of the largest manufacturers in the country, we are not confined to this type of production. Our organization and plant are equally geared to the molding of small quantities. Nor does the molding have to be a complicated piece to command our fullest attention.

Our capable engineering staff and modern molding equipment are instantly available to meet your slightest or greatest molding need.

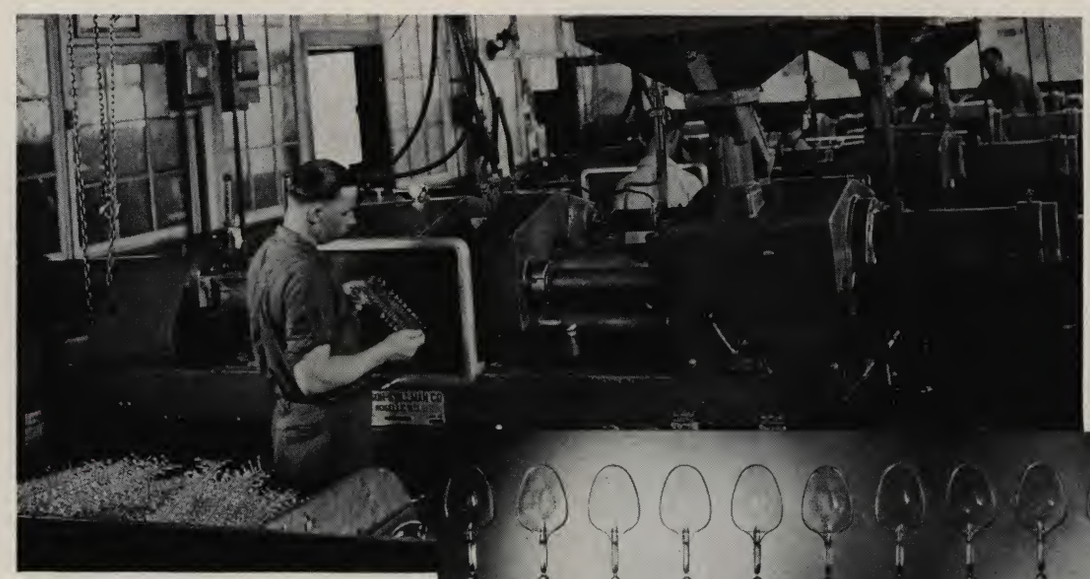


This tiny molding for hearing aid devices is also a product of Associated Attleboro Service.

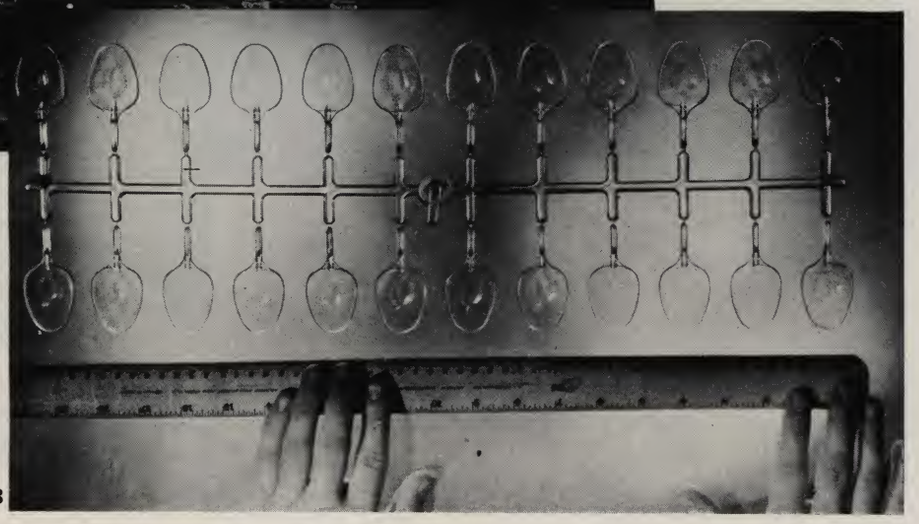
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ASSOCIATED ATTLEBORO MANUFACTURERS, INC.

New York Office: 303 Fifth Avenue · · · ATTLEBORO, MASS.



2



3

2—Line of Watson-Stillman injection machines doing custom molding. As far as possible all die plates are standardized making the frequently required changes relatively easy. 3—This casting shows thermoplastic transparent spoons just as they come from the press

Materials temperature

2. Practically all of the materials in the thermoplastic group are poor heat conductors. Consequently, there is a limit to the section or thickness of the compressed granules which can be properly plasticized. In our experience, cellulose acetate can be readily and quickly plasticized in a heated round section of $^1/_4$ in. diameter. On the other hand, some standard equipment on the market today contemplates a $^7/_8$-in. cross-section of material in the heating tunnel in which case the materials are heated from both sides. Unfortunately, no one yet knows how many calories of heat it takes to plasticize a cubic inch of a given formula of acetate materials. Consequently, the usual procedure of the machine manufacturer is to try out experimental heating tunnels under various conditions in order to determine their capacities. To play on the safe side, the equipment is usually rated with an ample safety margin below the maximum results secured. This procedure is also deemed necessary from the standpoint of average molded parts. Obviously, materials injected into a simple mold wherein a minimum number of material flow turns is necessary will require a lower capacity heating tunnel than a complicated die with many material flow turns and sub-cavities to be filled.

When there are no cooling problems involved, dies should be so designed as far as the number of cavities is concerned so that somewhere between 50 percent or 60 percent of the total tunnel capacity is utilized.

Many of the difficulties that had been encountered in the design of heating cylinders to prevent pocketing of material have now been overcome because of experience that has been obtained in successfully using less complicated construction inside the cylinder. In other words, a great deal of improvement has already taken place in heating cylinder design to obtain better plasticizing, create less back pressure and prevent burning.

Injection pressure

3. Injection pressures on the materials are important. Naturally, the speed of the production cycle is dependent on how cool, comparatively, you can run the molds. The faster you can fill the cavity or cavities *satisfactorily*, the colder the molds can be run and the more rapid cycles can be maintained. The mold design is also important from the standpoint of injection speeds since it is necessary for the incoming material to force out the expanding air in the cavities displaced by it as well as any gas which is usually prevalent. Theoretically, the quicker a die can be filled, the better; but there is apparently a limit for the various design pieces to be molded based on the dies, venting, cooling, etc. Very often in filling the cavities too rapidly, the expanding air and gas is trapped at some point in the cavity where it cannot escape.

In certain instances, under these circumstances, such air and gas is compressed to a point where it actually explodes, (*Please turn to next page*)

SPECIALISTS IN *PLASTIC ITEMS* FOR VARIETY STORE AND PREMIUM DISTRIBUTION



HEMCO PLASTICS

HEMCOWARE — A complete line of durable, non-staining plastic ware for children's dishes, picnic sets, kitchen items and toys distributed through chain, variety stores and department stores.

BEETLEWARE — A colorful line of low priced plastic items for premium advertising.

HEMCOLITE — A full line of Urea Plastics for all types of lighting applications, both domestic and commercial.

Products of HEMCO PLASTICS DIVISION

THE BRYANT ELECTRIC COMPANY • Bridgeport, Connecticut

A SUBSIDIARY OF WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY

similar to Diesel action, forming a small burnt spot in the material. To overcome such a situation without venting in the cavity itself, the design of the cavities should be such that they fill farthest from the parting line first, thus permitting the material to flow out to the parting line last, slowly and surely dissipating such air and gas.

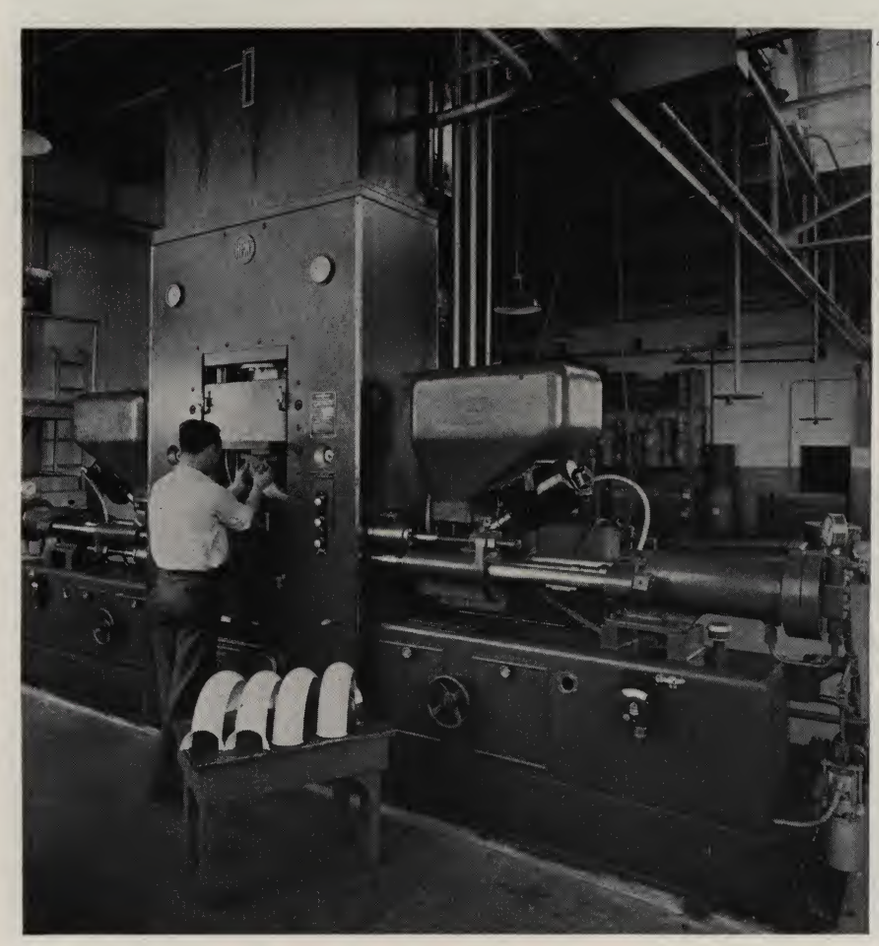
Experience in the last year has shown that faster piston speeds are not as necessary as previously estimated and in cases where heavy sections are being molded have even proved to be a detriment. As far as higher injection pressures are concerned, there are two schools of thought at present. One still advocates the higher pressure, claiming better physical properties in the molded article; the other claims that the higher pressure would put more strain on the molding equipment and is not necessary if the sprues, runners and gates in molds were made larger in size than some molders believe necessary. Their idea in keeping these sizes restricted is tied up mostly with the wish to keep the amount of material, which has to be reground, down to a minimum. By doing this higher injection pressures are required in order to force plastic material through these restricted areas and there is no evidence that the material actually entering the mold cavities is under any higher pressure than would be necessary if these areas had been enlarged. In other words, many molds requiring higher injection pressure could operate quite successfully at much lower pressures if the gates and runners were of sufficient size.

Clamp pressure

4. Clamp pressures on the dies must be sufficient to eliminate flashing during the molding operation. Such pressures should be so regulated and controlled that the mold will close quickly but will not be bumped or pounded as the halves or parts actually come together. There are many theories as to the amount of clamp pressure required by injection. When first introduced, it was estimated that, based on the projected cavity area, a clamp pressure of approximately 9 tons per sq. in. was required. While it is always safe to figure in such a manner on the larger parts, the equipment for such pressures would be prohibitively large and comparatively expensive. Again, a great deal seems to depend not only on the size and shape of the part but also on the design of the molds. Experience, especially on the larger parts, indicates that clamp pressures of from 3 to $3^1/_2$ tons per sq. in. of projected cavity area are sufficient.

Mold temperature

5. Mold temperatures should be held constant in order to secure not only the best but uniform molding results. Inasmuch as the finished side of a part can be molded with a higher luster and greater smoothness by the use of higher temperature, it is very often desirable to run this side of the die somewhat warmer than the opposite or unfinished side. Mold temperature controls are be-



4—This H-P-M multiple-cylinder injection machine is in production on a top piece for gasoline pumps. The large capacity of the unit permits the production of huge parts such as these. The machine operates throughout on hydraulic pressure

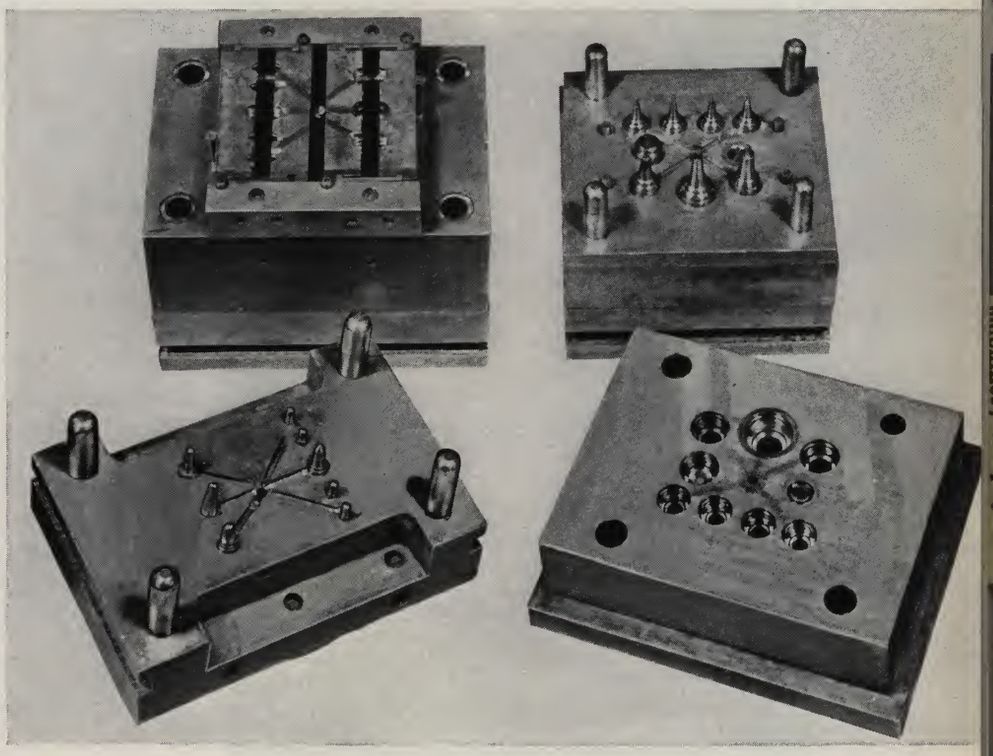


The Prize Winning Mold Steels

Prize winning chessmen molded in Tenite for Gallant Knight, Inc. by the Ability Mold & Die Mfg. Co., Chicago, who also made the mold of *Speed Case* free machining low carbon steel.

- **in the Plastics Competition**
- **in the Tool Room**

Speed Case **and** ***Speed Treat*** **win prizes for the plastic products formed in molds of these steels and they are prize winners in the tool room, too. They machine more freely and reduce grinding and polishing time. Tool costs are lower. They have high strength, heat-treat more readily and retain exact contour in use.**



SPEED CASE

A low carbon open hearth hot rolled plate steel. Carburizes in 5 to 25% less time, a deep uniform case with a hardness of from C62 to C66 Rockwell resulting. *Speed Case* can be "hogged out" with heavier feeds and at higher cutting speeds. Mold makers using *Speed Case* report mold costs reduced up to 59%, molds that stand up better, and better molding on even the most delicate or intricate work.

SPEED TREAT

A medium carbon open hearth free machining hot rolled steel plate of high tensile strength, excellent compression, impact and abrasion resistance and high yield point.

Recommended for large molds and dies where maximum strength is required. Withstands constant temperatures up to 700°F. without checking.

Send for your copy of "The Story of *Speed Case*" —gives all the facts on these cost cutting steels.

SPEED CASE FREE MACHINING OPEN HEARTH STEEL PLATE

Quality Controlled *Speed Case* and *Speed Treat* Steels are available in all common plate sizes, hot rolled and cold finished bars and billets.

W. J. HOLLIDAY & CO.

Established 1856

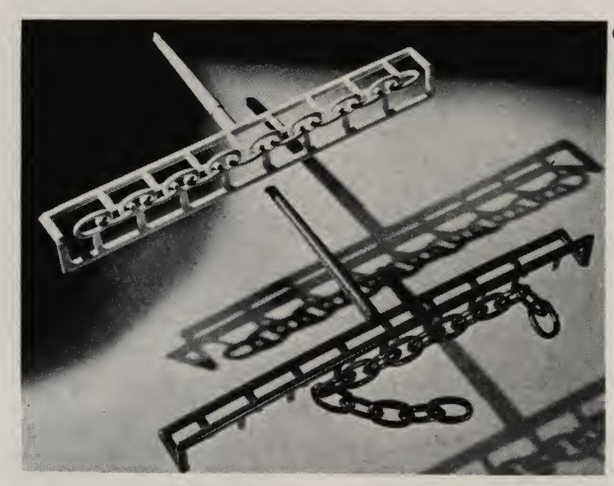
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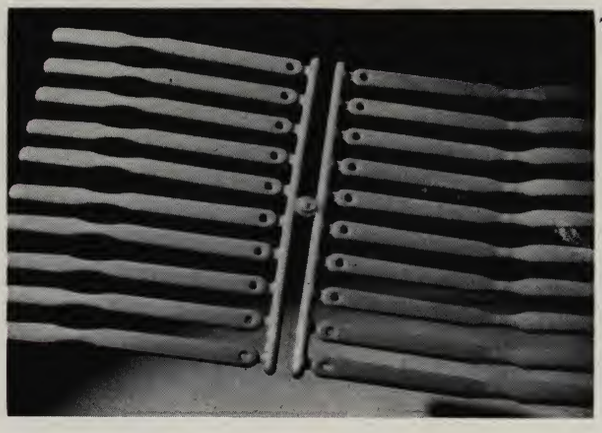
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5



6



7

5—Combination broom bristle housings and handle tips successfully incorporated four on one sprue casting for injection molding on a Reed-Prentice Machine by Elmer E. Mills Corp. 6—An extremely interesting intricate injection molded chain by Tilton Cook Co. Neither gates, sprues nor runners have been detached. 7—Tooth brush handles are now widely injection molded, often 20 on a sprue as shown

coming more important also from the standpoint of new materials and new formulas for the present materials which must be injected into dies heated to a higher temperature than the hot materials will maintain. In such cases the production cycle is not always affected as the pieces can usually be ejected from the mold at a somewhat higher mold temperature than it is found necessary to maintain.

Owing to the youth of the art, no one knows at the present time just what the limitations of injection molding will be. No one is prepared to definitely state how thin or how thick a section could be molded because each time one believes he has formulated a reasonable formula, he finds an application which disproves his theories. In fact, this whole phase of the industry at the present time is in such an embryo state that it would be impossible for anyone to evolve a series of formulas either for mold design or for molding procedure. Many of the suggestions of young engineers on mold designs are very valuable because of their unorthodox methods.

Injection molding thermosetting plastics (transfer molding)*

The average person engaged in the plastic industry today usually thinks of thermoplastic materials when he discusses the subject of injection molding, and if the term "injection molding" is used in reference to thermosetting materials, he is very apt to assume that you mean "Transfer" molding.

The reason for this differentiation is easily understood when one stops to consider that the injection method is ideal for the utilization of a *cool* mold for the handling of thermoplastics, whereas with the Transfer molding method the mold cavity is maintained at the high temperatures required for curing the thermosetting materials. The property of thermosetting molding powders which permits ejection of the piece from the mold without cooling is an advantage not to be discarded, and present-day injection molding of thermosetting resin is based on a *cure* period in the hot mold analogous to the *cooling* period required for the thermoplastic materials. As is the case of the injection molding of thermoplastics, a careful balance of mold temperatures versus cylinder temperatures must be maintained. If the latter temperature is too low, insufficient flow is, of course, obtained with both material types. However, if the temperature is excessive, it is possible actually to cure or "set up" a thermosetting material within the cylinder and cause jamming of the machine. Thermoplastics would tend to discolor and *burn* but jamming of a machine due to loss of plasticity is quite unlikely.

The technique of "Transfer" molding and the advantages to be gained by this molding method have been thoroughly covered in the literature.[1,2,3] From these literature references, it does appear that while considerable thought has been given to the construction of special presses for simplifying and speeding up the "Transfer" method of molding, it is only recently, within this country, that the injection molding machine has been investigated for this purpose [4] It is understood, however, that the investigators have all found it necessary to alter the injection machines used so as to adapt them for the molding of thermosetting molding compounds.

(*Please turn to next page*)

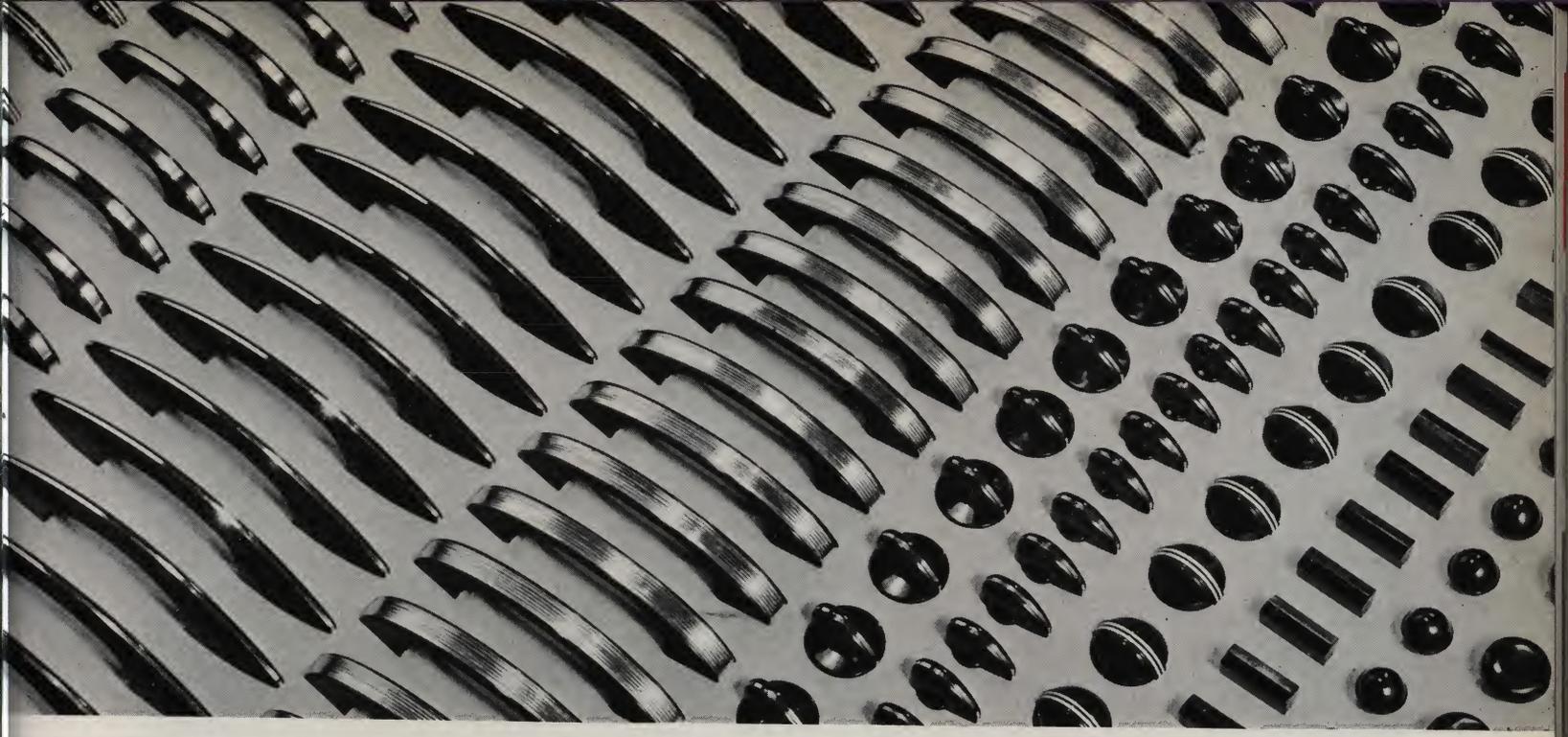
* This section was especially prepared by L. M. Debing Resinox Corp.

[1] U. S. Patents Nos. 1,916,495 and 1,919,534 assigned to Shaw Insulator Company; Nos. 1,993,942 and 1,997,074 to Novotny and assigned to Shaw Insulator Company.

[2] "Transfer Molding," Modern Plastics, April 1939.

[3] "Transfer Molding," Modern Plastics, October 1939.

[4] "Injection Molding of Thermosetting Resins," Modern Plastics, June 1939.



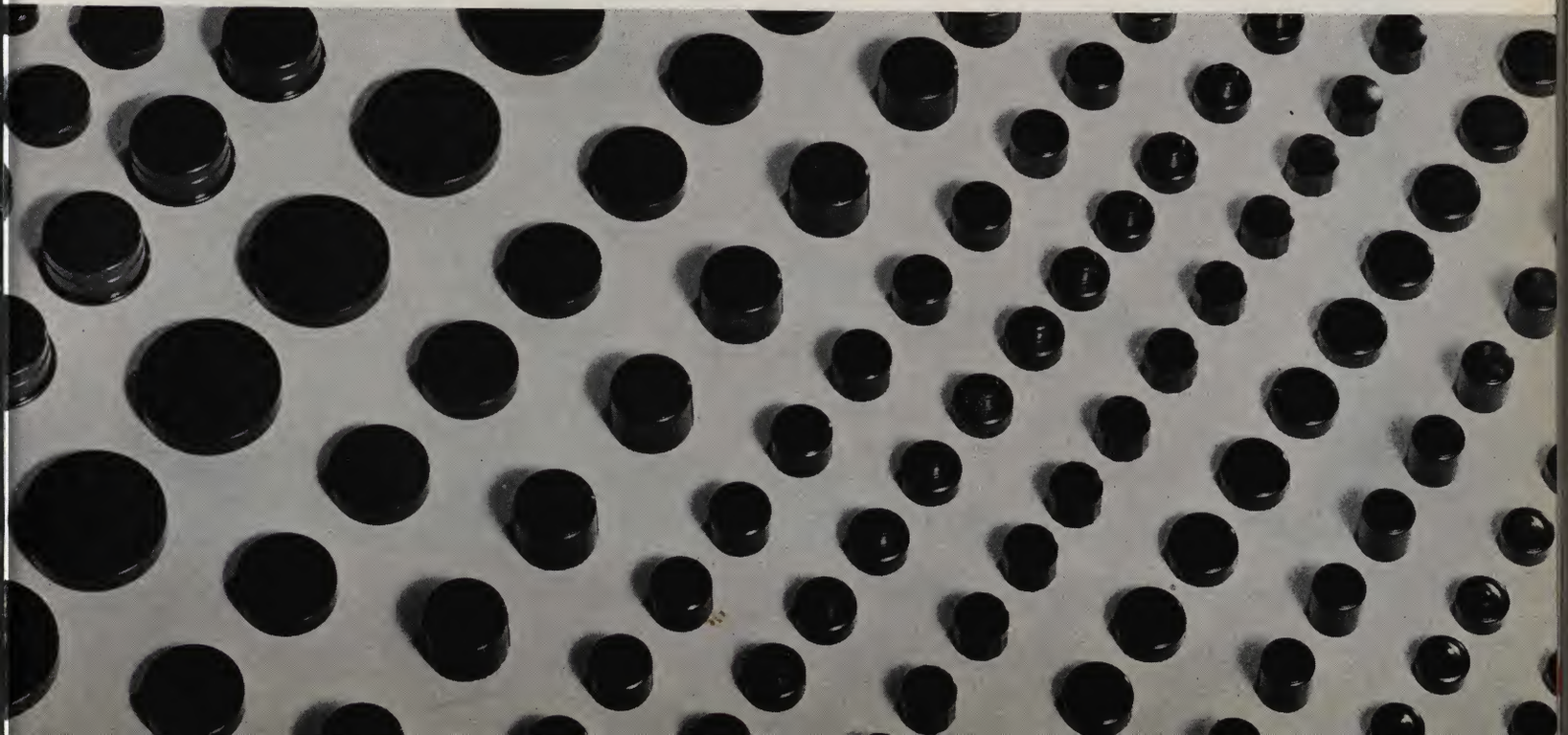
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Figures 8 and 9 illustrate in a very elementary way the technique involved in the molding of a simple disk by compression and injection molding. Fig. 10 illustrates the technique involved in injection molding the same object. The sketch (Fig. 9) shows "Transfer" on a "one shot" basis, while Fig. 10 shows essentially the same method wherein a plastic charge is ready for the second molding cycle, and time is not required for plasticizing a new charge of powder.

The advantages to be gained by the injection molding of thermosetting materials are, from the standpoint of cost, approximately the same as those for thermoplastic materials, with one notable exception. The sprue of thermosetting material cannot be reworked, as is the case with thermoplastic materials. However, one large manufacturer on an experimental job found an actual saving in the powder required to make a piece weighing approximately one-half pound. This was due to the fact that the piece ordinarily made by compression molding required an excess charge to insure proper filling out of the piece, and no excess material for this purpose was required in injection molding. There are, no doubt, many jobs today which require the properties of molded phenolics, and yet cannot be produced cheaply, due to the high cost of multiple cavity molds required for economical compression molding. The number of shots per minute will depend on the article to be molded. However, a 20-second cycle has been obtained in the experimental molding of 28-mm. caps.

The costs to be considered in the molding of an article are: (a) the initial mold costs; (b) the overall operating costs; (c) finishing costs; and (d) the molding powder costs. As already stated, the initial mold cost can be somewhat reduced by the injection molding process, and whether or not a marked reduction in operating cost can be obtained over other conventional molding methods will depend on the initial judgment of the molder as to whether or not he selects the proper method and mold design for the job in mind. The relationship of mold operating costs to the number of cavities for injection molding versus compression molding has been well covered in an article entitled "How Do Costs Compare?"[5] As for the cost of molding powder, it has already been shown that ordinary wood-filled phenolics are satisfactory. Material manufacturers will no doubt find means of improving the working qualities of their molding powders, and it appears that a wide latitude in processing will be possible, since mechanical mixtures of phenolic resin and wood flour have been molded fairly satisfactorily. Such unprocessed material is, of course, considerably slower curing than a properly processed material, and the quality and uniformity of articles molded by such a procedure would require careful study to ascertain their true worth. The high bulk factor of such a mechanical mixture would materially cut down the capacity of the machine. The bulk factor of the various grades of molding powder is also a factor to be considered.

The foregoing is intended as an introduction to a subject about which little in the way of commercial acceptance is yet known. At some later date, the true worth of this new molding technique will be more easily

[5] Modern Plastics, 17, No. 6, page 28, February 1940.

Fig. 8

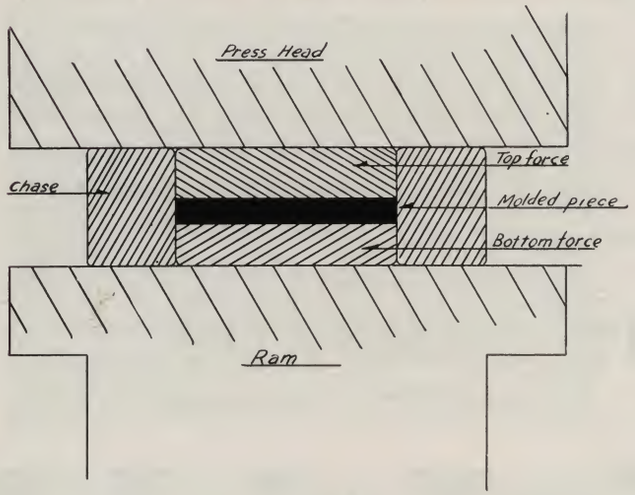
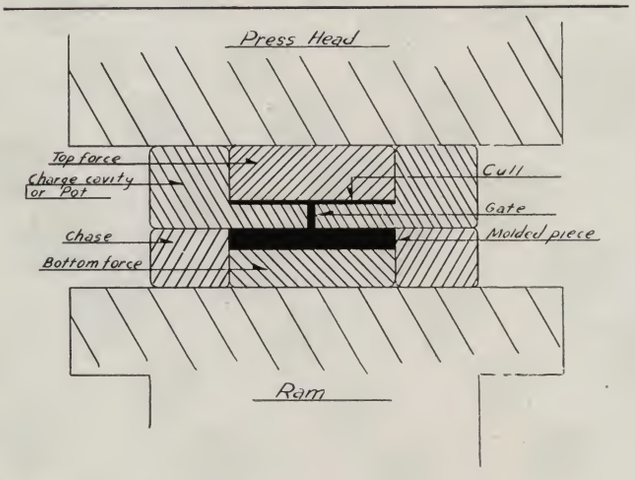
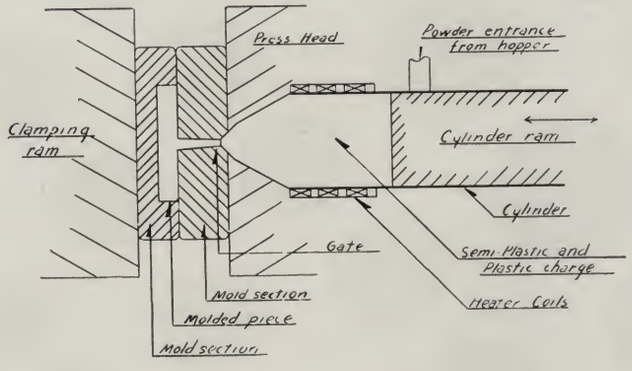


Fig. 9



8—Diagram shows the elemental features of compression molding. 9—In one method of molding thermosetting material the required amount of material is placed in upper cavity. Heat and pressure force material into lower cavity. 10—This demonstrates essentials for continuous injection molding

Fig. 10





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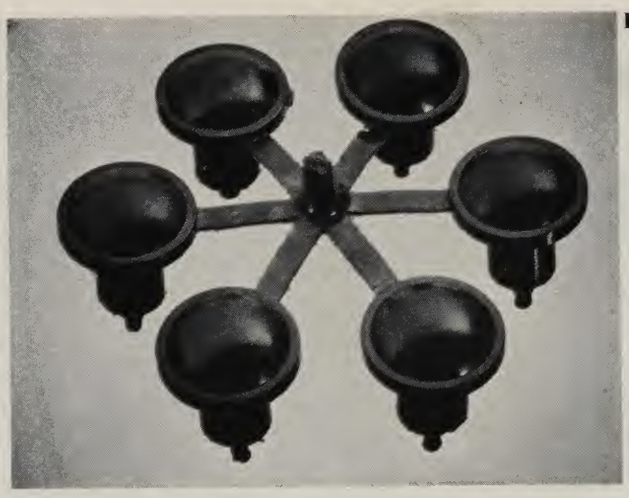
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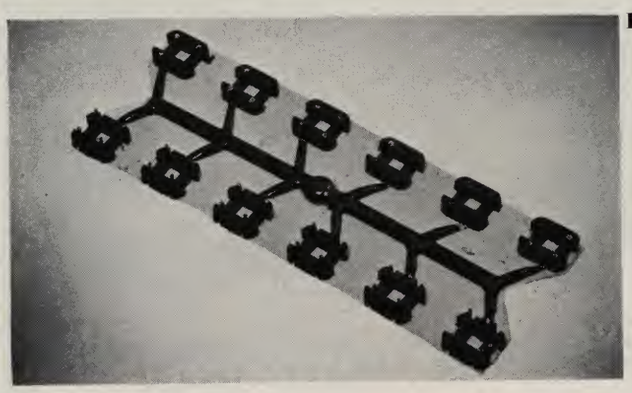
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11



12

evaluated. Some of the possible advantages and disadvantages of injection molding are summarized below, and it appears that the possible advantages to be gained will warrant continued development of the injection molding of thermosetting materials.

Possible Advantages to Be Gained:

A. Elimination of preforming.
B. No preheating required.
C. Increased production per mold cavity.
D. Lower mold cost and mold maintenance cost per unit of production.
E. Reduction of finishing costs.
F. Increased quality due to the greater density of the pieces obtained.
G. The "thousand lot" job will not be smothered by initial mold and operating costs.

Possible Disadvantages:

A. The percent powder loss may be higher than that of other molding methods, due to the loss of an unworkable sprue.
B. The variety of moldings possible will, no doubt, be limited by the tendency to precure the cylinder charge during the cure period required for the piece.

13



11—Knobs with sprues and runners attached as they were removed from press. They are injection (transfer)molded from phenolic material. 12—Small electrical parts with inserts injection molded from phenolic powder. The method enables the inserts to be held to close tolerances. 13—Thermosetting electrical parts such as these requiring inserts are produced on a large scale by injection. (All molded by Shaw Insulator Corp.)

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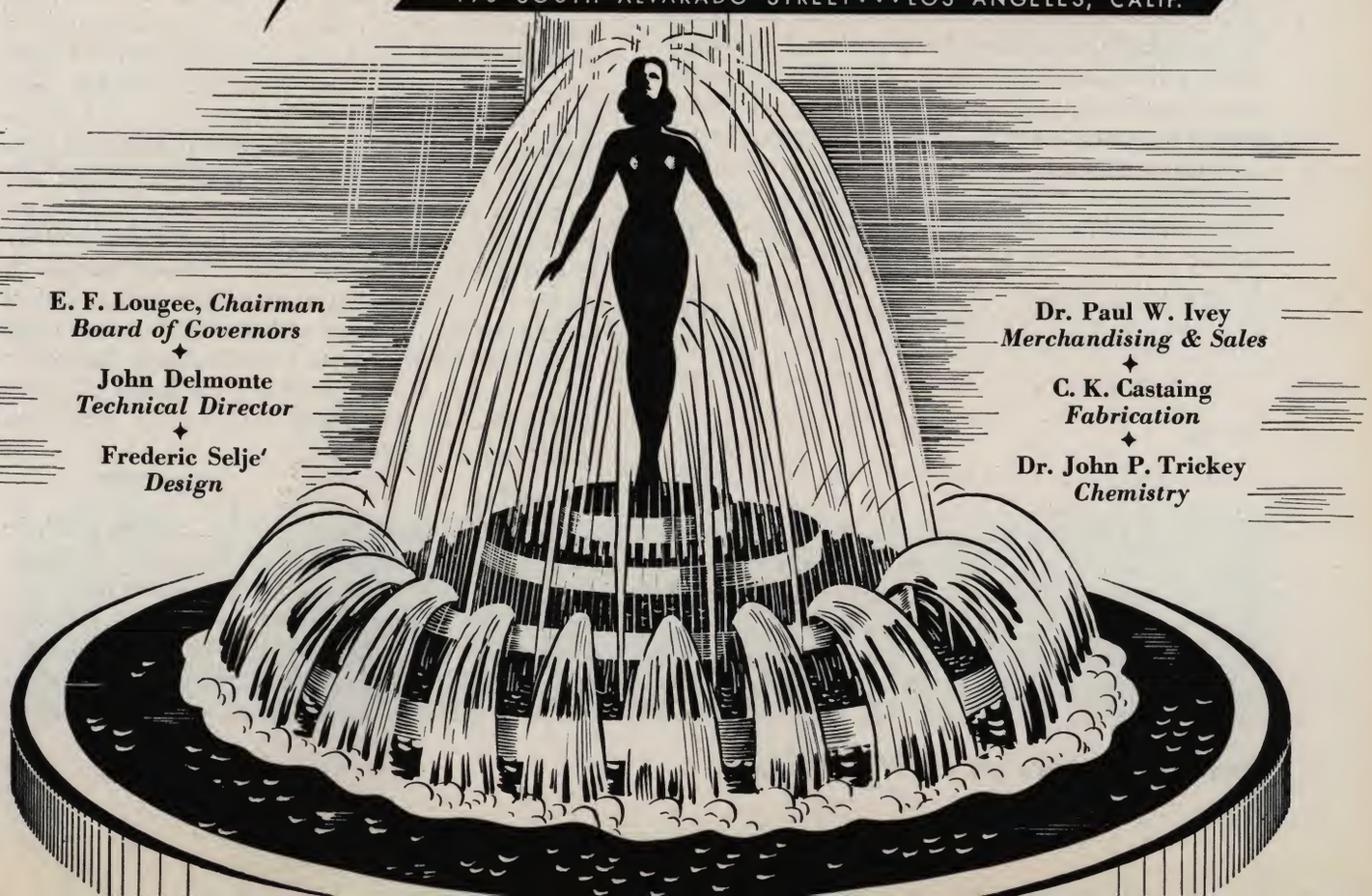
As a comprehensive source of practical plastics education, the Institute feels its responsibility to the plastics industry and has designed its entire curriculum to serve plastics in the most efficient way. Thorough training is offered, including the history of materials, their types and characteristics, mold design, molding, laminating, fabricating, product design, market possibilities and methods of testing.

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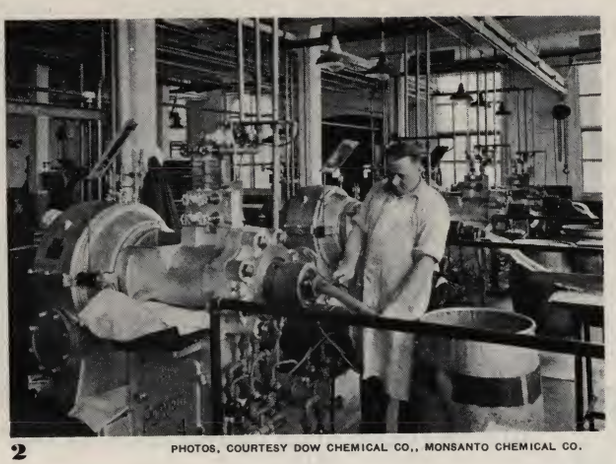
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1



2

PHOTOS, COURTESY DOW CHEMICAL CO., MONSANTO CHEMICAL CO.

1—Close-up view of extrusion head in production on small diameter sections. 2—Large screw type extrusion units processing continuous length rod

Continuous extrusion

EXTRUSION, a process which seems to have caught the imagination of plastics fabricators almost over night, is not new, and it is surprising that a method of fabrication, which is so well adapted to volume production, should have been neglected so long. Continuous extrusion with the use of a solvent is a very old process. Burroughs made the first machines for the extrusion of cellulose nitrate paste (cellulose ester plus plasticizer and solvents) in the form of rods and tubes about 1890. Continuous extrusion without a solvent is commercially new. The fundamental principles of extrusion without solvent are relatively simple. A thermoplastic material is softened by heat, forced through a shaping die and allowed to cool. This process often has been likened to injection molding, which is sometimes termed "extrusion molding." While both operations do have points of similarity, they differ widely in two fundamental respects: (1) In contrast to extruded shapes, injection molded parts need not be uniform in cross section throughout their length; (2) in injection molding the heat-softened plastic accepts almost the exact shape of the mold *into* which it is forced, while in extrusion the plastic takes approximately the shape of the die through which it passes and is forced out in continuous lengths.

The die

The design of the die is regulated, to a certain extent, by the type of plastic to be extruded, as well as the size and shape of the part to be made. However, it is seldom necessary to design long dies. Upon leaving the die, the plastic form is usually stretched to a greater or lesser extent, so the size of the opening is generally larger than the corresponding dimension of the extruded and stretched part. This is particularly true if the passage through the die is long. The shape of the extruded part, in some cases, differs materially from that of the die opening, so that when a given shape is desired, this change must be considered in the design of the die. Fortunately, extrusion dies are relatively inexpensive, and experimentation may be conducted on a much less costly scale than is possible in the case of injection, or conventional, molding practice.

The take-off

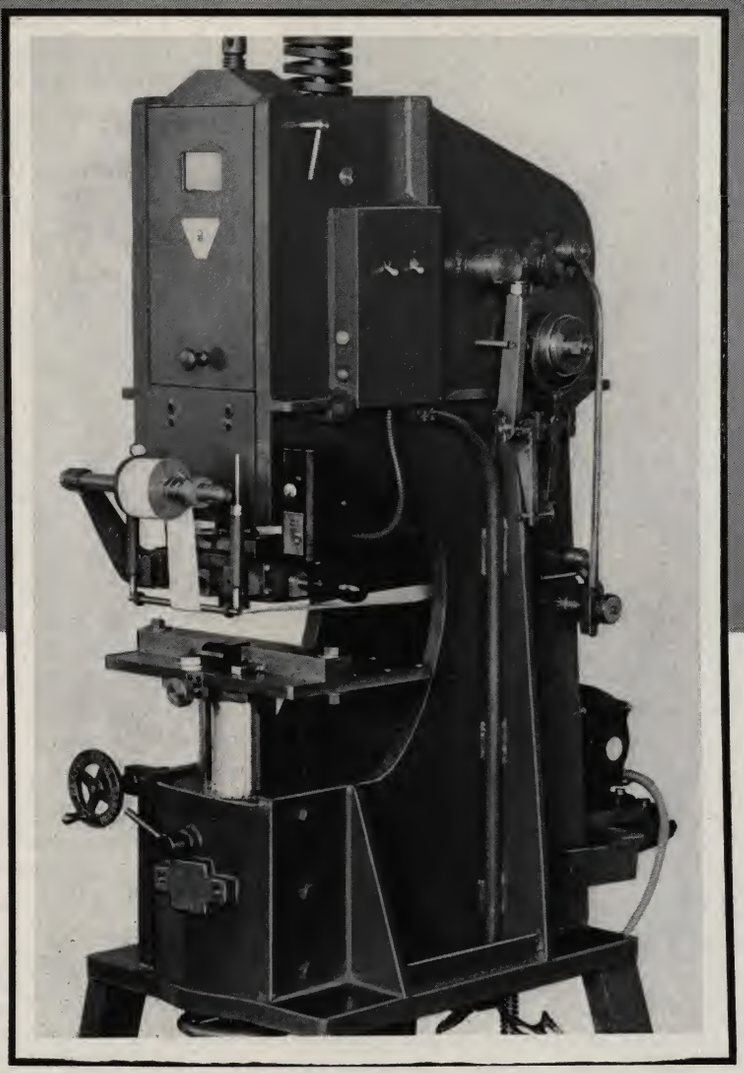
The extruded material as it issues from the die is soft and easily deformed. Hence, provision must be made for its reception, removal and cooling at a controlled speed and in such a manner that deformation may be avoided. For simple shapes, a moving belt is a suitable take-off and cooler. Special handling methods, however, are required for more intricate and more delicate shapes. The design and operation of the take-off is especially important in the case of plastics which must be heated to a high temperature to develop gloss and good physical properties. Such plastics are extruded in a very soft condition, and as a consequence do not readily retain the die shape. It is important, therefore, to consider the properties and possible reactions of the plastic material to be used before building the receiver or conveyor. A more complete discussion of plastic materials which can be used for extrusion is contained in subsequent paragraphs.

The wind-up

Small flexible extruded shapes, i.e., tubing or rod, frequently may be wound into coils upon leaving the conveyor and cooler. If an automatic wind-up is provided for this purpose, it must be so designed that it maintains a peripheral speed corresponding to that of the conveyor, in order to avoid stretching the plastic shape at the point near the die opening where it is soft and pli-

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able. Extruded goods which are rigid or of large cross-section generally cannot be wound without deformation and must be cut into the desired lengths.

The material

Plastics for extrusion should be specifically designed for that purpose. In some materials they are available in grades ranging from soft, through tough and flexible, to hard and rigid. These are formulated to make the extrusion temperature range as wide as possible, and to promote retention of shape while cooling.

In extrusion without solvent, the plastic must be dry for best results. The presence of a very small amount of moisture in the hot extruding section is sufficient to cause blistering and roughness. Complete dryness of material is even more important in extrusion than it is in injection molding.

Most of the thermoplastics, with the exception of the cellulose nitrate group, can be extruded hot by the method described. However, certain of the others require a special technique. The vinyl chloride polymers and co-polymers can be extruded in properly designed machines and yield products which vary from the hard, rigid and brittle type to those which exhibit remarkable toughness and flexibility. Cellulose acetate, cellulose acetate butyrate, and ethylcellulose plastics also can be extruded. Webbing for the upholstery of lawn furniture, now a currently popular application for extruded plastics, has been made possible by the availability of extrusion materials resistant to exposure out of doors.

Control and distribution of heat

The machine for extruding plastic is so arranged that the die holder, and head, body and feed sections can be heated separately. This makes for flexibility in control. Some materials behave better if the feed section of the machine is cooled. In some cases, it is heated only by conduction from the adjoining sections, but for materials requiring the greatest amount of heat to become plastic, it may be heated to any temperature within the range of the heating system. In general, it has been found best to decrease temperatures progressively from die holder to feed. This may be done by passing the heating medium through the sections in series, with the input at the die end. A considerable gradation of temperature can be secured by reducing the amount of heat transfer medium pumped through the system. Since each plastic has its characteristic behavior and heat requirements, no general rule can be formulated for materials and sections.

Extrusion technique

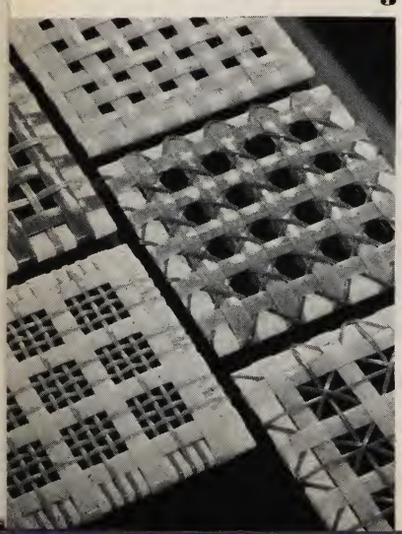
The technique for plastic extrusion differs somewhat from that for rubber in which the feed strip is often throughly pre-warmed on a mill, the extrusion machine serving principally to form the strip into the desired shape. The plastic extruder is longer than that used for rubber, the additional length being required for the heating and working of the mass into a homogeneous state. In order to realize the full benefit of the longer tube, it should be kept filled at all times. Otherwise, the in-going plastic may be rapidly forced along the tube, with little working, until it meets the back pressure from the die. While very small single strip extrusions may be made in this manner, and actually may be better for the shorter time allowed in the heating zone, it is obvious that the maximum capacity of the machine can be obtained only if the entire heating area is utilized by keeping it full.

When using a machine at low-capacity output, a carefully adjusted feed for the plastic granules is required. The rapidity of the revolution of the extrusion screw is not necessarily reflected directly in the quantity of the machine's output, since some slippage of material back along it is always present. This becomes greater in relation to the discharge through the die as screw speeds are increased and viscosity is reduced. In extreme cases, a regurgitation of softened plastic into the feed opening may result. Such difficulty is not likely to occur if the die opening is large and head pressure is relatively low.

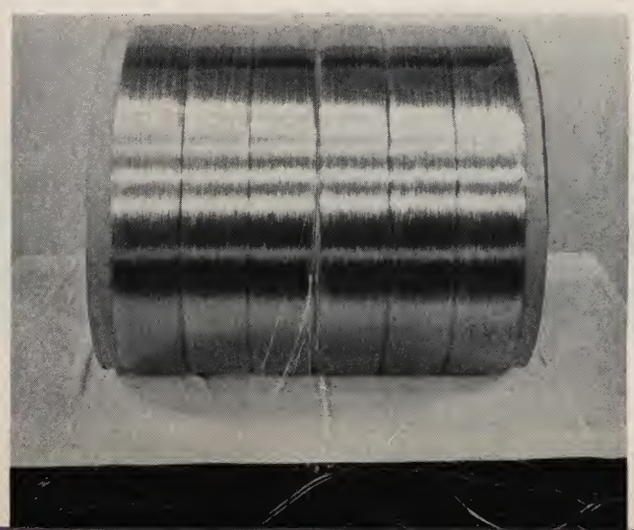
Conclusion

It is practically impossible to describe all the conditions necessary to the proper extrusion of plastics, and any discussion must be limited to a description of processes in general. Requiring good control and at times considerable mechanical ingenuity, extrusion is capable of producing forms of regular cross section continuously, economically and with very little waste. It is a process with great promise, one which should be—and in the light of present developments probably will be—used far more generally than heretofore has been the case.

3



4



3—Fancy designs of woven aceto-butyrate mesh demonstrating versatile possibilities of applying extruded Tenite II shapes for furniture. 4—Fine gage extruded vinylidene chloride fibers produced by Pierce Plastics, Incorporated

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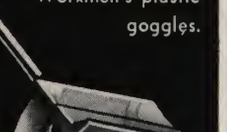


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Workmen's plastic goggles.



Throttle control button.



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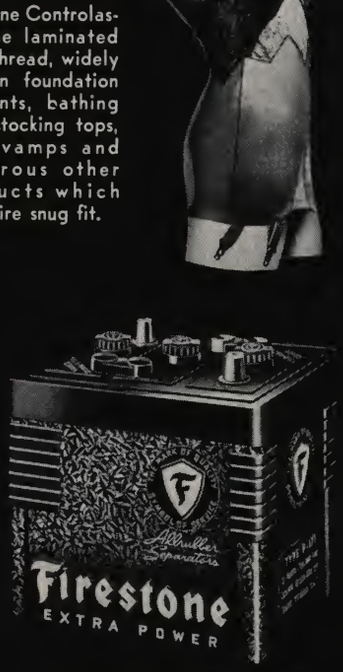
Plastic radio cabinet which won first prize in competition sponsored by Modern Plastics magazine.



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Casting phenolic resins

WHILE casting polymerized phenol wasn't the first method adopted for treating with this important class of material it has come into an important position in the industry today. The progress which the material has made has been accelerated by the technical advances which are still occurring. They involve both improvements in material, and the construction of the molds used for casting and machining operations.

Lead molds

For the production of lead molds, as is well known, a steel master mold is dipped into molten lead. The arbors are then withdrawn from the lead. After cooling, the lead molds are withdrawn from the steel forms. The process can be repeated as often as desired and consequently the production of lead molds is cheap. Expenses for the master mold are relatively low and this makes it possible to have a steel form made for smaller production runs.

With the above-mentioned method only *one-piece open molds* can be made and, therefore, only simple shapes with no undercut can be fabricated.

The demand of the industry for production of intricate castings increased and it was essential to try to make *split lead molds*. There were some difficulties to overcome as it is not possible in this case to withdraw the lead molds from the master forms as can be done with open molds. The two parts of the mold have to join perfectly and a good sealing has to be provided. The big problem was to make the split molds at about the same costs as the one-piece molds.

When finally all these problems were solved it became evident that still some technical difficulties had to be overcome. When cast resin is poured into lead molds, air gets into the mass. At the beginning of the curing process the material gets thin and the air bubbles rise to the surface where they burst. When split molds are used, the air bubbles rise up to the undercuts. When the same resin as in single molds is used, the material gelatinizes before the air bubbles can get away from the undercuts. A way had to be found to produce a more liquid material which retained the good qualities of the regular material like transparency, toughness and good machinability and at the same time was liquid enough to allow the air bubbles to find their way out of the undercuts to the surface. With this accomplished there are no more difficulties today in the manufacture of split lead molds and the costs are about the same for these as for the one-piece molds.

For the cast phenolic resin industry, this is of great importance. Now, even intricate articles can be cast without much waste of material and without too high expense for labor. Up to now such articles could be produced only by means of pressure or injection molding, but in such cases the die costs are pretty high on account of the high pressures involved, compared with the mold costs for split molds. Besides, these molds can be built

1—In casting phenolic resins, lead molds are filled by hand with the prepared resin. These are for cutlery handles. 2—Having been baked to required hardness, the cured casting is removed by tapping the bottom of the mold with a hammer. (Photos, courtesy Marblette Corp.)

1



2



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Philco needed a cabinet which would combine minimum weight, maximum durability and compelling eye appeal for this new portable radio. The weight of this housing is negligible, the walls are so thin that the outside measures only slightly more than the interior—yet the cabinet is strong enough to withstand the knocking about which any portable radio must get. An ingenious feature of the design is the incorporation of a loop antenna in the carrying strap.

• JEWELITE DOOR KNOBS

Molded for Keystone Brass & Rubber Co., Philadelphia, Pa.

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• SHOWER HEAD

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By injection molding we have been able to give the Mueller Brass Company metal milled accuracy, with rapid molding cycles. Merchandising advantages: the color possibilities of the materials make it possible for each housewife to match her bathroom decorations. These shower heads have revolutionized the buying habits of decorators and consumers and are being sold in tremendous quantities throughout the country.

• INSTRUMENT PANEL

Molded for the Aeronautical Corporation of America, Middletown, Ohio.

This is the first time that modern plastics have ever been used in this application to dress up the interior of an airplane in cream-colored materials. Four sections are used to frame the various instruments. Each of these sections is much lighter in weight than any other finish material and the improvement in the appearance of the cabin's interior has been so marked, according to the manufacturers, that a tremendous sales increase is anticipated.

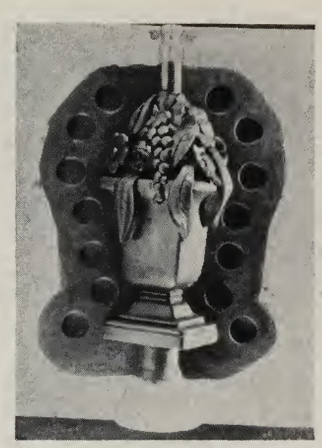
Plastics can solve a variety of merchandising and production problems, as evidenced by these prize-winners. The same quality service which produced them is available to you.

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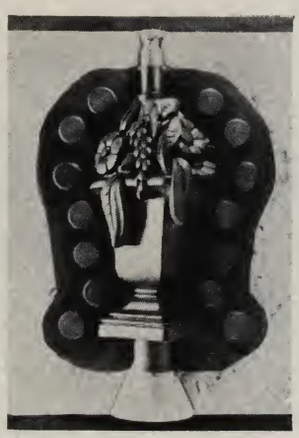
STANDARD PRODUCTS COMPANY

THERMO-PLASTICS DIVISION

505 Boulevard Building, Detroit, Michigan · · · Factory: St. Clair, Michigan



3



4

3—Section of rubber mold showing plaster of Paris backing and interlocking studs. 4—The other section of same mold. (All photos courtesy Galvanic Art Studios)

within a much shorter time, therefore split molds can be used especially for smaller quantities of merchandise without increasing the cost of the articles too much.

An increase in business has been brought about for the use of cast resin because a great line of articles is now available for fabrication at a lower price on a commercial mass production basis, as, for instance, cigar and cigaret holders, shaving brush handles, carved buttons, buckles, lamp stands and handles for all purposes and a variety of other carved articles with undercuts.

Rubber molds

It has been pointed out elsewhere (see page 32) that in the production of articles from phenolic resins relatively low temperatures, 80 deg C, and no pressure are required for the proper curing of the material. For many years this feature has appealed to individuals and companies wishing to reproduce *objets d'art* or models in small quantities and involving complicated undercuts and compound curves. While this has been done with clay, plaster of Paris, and various types of fibrous compositions, there has been a continual search for a material resistant to water, having a hard smooth surface, and available in a variety of colors.

Experimental work was conducted simultaneously in widely separated sections of the country, and many materials were used in making flexible molds from which complicated castings incorporating undercuts might readily be removed. Various types of rubber were among the leading early mold materials, but after innumerable experiments it was found that latex rubber offered the best resistance to heat, furnishes the smoothest surface to the casting, and was otherwise amenable to the demands of rubber molding of cast phenolic pieces.

The technique may be divided into three main classes, each of which is subject to minor modifications dictated by the type of article being molded and the production rate required. These are: (1) Solid Castings, (2) Slush Molded Castings, (3) Cored Castings.

Solid castings. This method is usually employed where *objets d'art*, figurines and small articles are to be produced. It is also used where transparent colors are to be employed because a better depth of color can be had if the casting is solid.

A master model is first prepared, using plaster of Paris in most cases although wood, stone, metal or any other material may be used equally well. Usually the article to be reproduced will serve as a master model without any special preparations except to see that the surfaces are smooth. The model is coated with liquid latex, using a brush, although spraying and dipping have been tried with fair success. Several types of latex have been developed which are resistant to heat and the action of the resin. Inasmuch as one coat of latex produces a rather thin and flimsy film, several coats are required, depending on the size of the article to be reproduced. In general, it may be said that a $1/8$-in. coating of latex will suffice for articles up to 2 in. over-all diameter, $1/4$ in. for articles up to 4 in. over-all diameter, and $1/2$ in. for larger pieces.

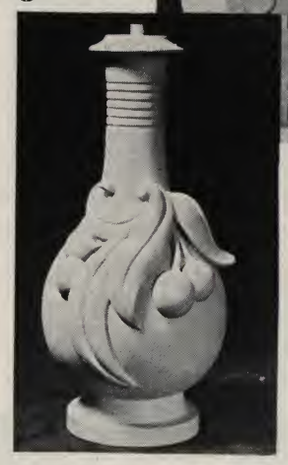
When the model is thoroughly covered with latex to the required thickness, the latex is then backed with a $1/2$-in. to 1-in. coating of plaster of Paris to give rigidity to the mold and permit its being handled without destroying the details and the contours or disfiguring delicate undercuts.

In many cases undercuts are of such depth and widely divergent planes that in these instances it is necessary to split the plaster of Paris and the rubber mold underneath it into three or more sections, but in general two sections are all that are required owing to the extreme flexibility of the latex. (*Please turn to next page*)

5



6



5—A section of a rubber mold showing the type of collapsible core employed at right. 6—The finished cast resin piece after removal



TYPICAL 1941 "SEE-DEEP" PLASTICS

CARDINAL CORPORATION

EVANSVILLE, INDIANA

Using a convenient point of division, the plaster of Paris coating is split into two parts and the rubber mold underneath it is split at identically the same point. This yields two halves of a rubber mold incorporating the design of the model. These halves will each fit into their plaster of Paris backings, and by clamping them together, a hollow, plaster of Paris, two-piece mold lined with latex is formed. Through the opening at the top of the mold liquid resins properly colored may be poured into the mold and subsequently cured to their proper hardness.

In locking the sections of the mold together two methods are commonly employed. In one method interlocking studs are incorporated in the rubber, as illustrated by Figs. 3 and 4 on page 228. In the other method the edges of the rubber mold are brought together and lightly coated with latex rubber in order to seal them, and the locking devices are incorporated in the plaster of Paris backing. In both cases a rigid mold is obtained which can be used from 25 to 150 times.

There are three methods of curing the liquid resin which has been poured into the rubber mold; one, heat curing it; two, acid-accelerator curing it; three, a combination of the first two methods. In heat curing the resin, the mold containing it is placed in an oven and a temperature of 176 deg F is maintained for 48 to 72 hours. In acid curing the resin is mixed with hydrochloric acid in the proper proportions or with special accelerators which have been developed for use with transparent resins, and allowed to harden cold from 1/2 to 6 hours, depending on the size of the casting and the proportion of accelerator used. A combination of heat and acid is used where speed of production is paramount. It goes without saying that the best castings may be secured by using heat only, and the appearance of the castings and the richness of the colors are dependent upon the proportion of acid used.

Phenolic resins are usually colored with aniline dyes, but because of the corrosive action of the acid, colored castings using accelerator cannot be obtained unless pigment dyes are employed in the coloring process, and depth of color is sacrificed to the demands for speedy production in these instances.

Slush molded castings. This process involves molds similar to those used in solid molding except that the orifice through which the material is poured is somewhat larger, although this is not essential. Since the resin must set up quickly in slush-molded articles, accelerators are used in varying proportions and frequently combined with heat.

The liquid resin is mixed with the accelerator in the proper proportion and a predetermined amount of material is poured into the opening of the mold. Various mechanical devices have been developed into which the mold can be set and moved about on different planes in order to slush the material evenly around the inside of the mold. As it moves about in the mold it hardens in a manner similar to the hardening of lead in the manufacture of slush-molded lead soldiers and similar novelties. This process consumes from 15 minutes to one hour, depending upon the proportions of accelerator used and the required thickness of the sections of the casting. As soon as the article is properly cured the mold is opened, the casting removed, and the mold is re-used.

Surface coloring of the casting is preferred, but acid-resistant pigments can be used if the resin is to be completely colored throughout.

Cored castings. Because pigments will render transparent resins translucent or opaque, it has been impossible to slush mold transparent phenolics. To overcome this limitation, collapsible rubber cores have been incorporated in rubber molds, as illustrated by Fig. 5. The core on a metal nipple is fastened into the plaster of Paris surrounding the rubber mold and expanded to its proper dimensions with compressed air. Transparent resin, or desired colored material is poured into the mold and cured, using heat in the case of transparent material or a combination of heat and acid in the opaque or translucent materials. The mold remains in the oven until cured to the proper hardness, after which the core is deflated, the mold opened, and the finished casting is then removed.

In all of these operations the surfaces of the castings are quite smooth, although fins which appear at the point of the union of the mold sections must be filed from the castings. Fig. 8 is a rough casting as it is removed from the mold and Fig. 7 is the same casting colored with lacquer as it appears in the finished display. Fig. 5 is the rough cored casting as it was removed from the mold illustrated in Fig. 6.

7



8



7—Finished display for Lily of France designed by Margaret Porcher. 8—The rough casting. (Courtesy Ann Turner Donahue Displays)

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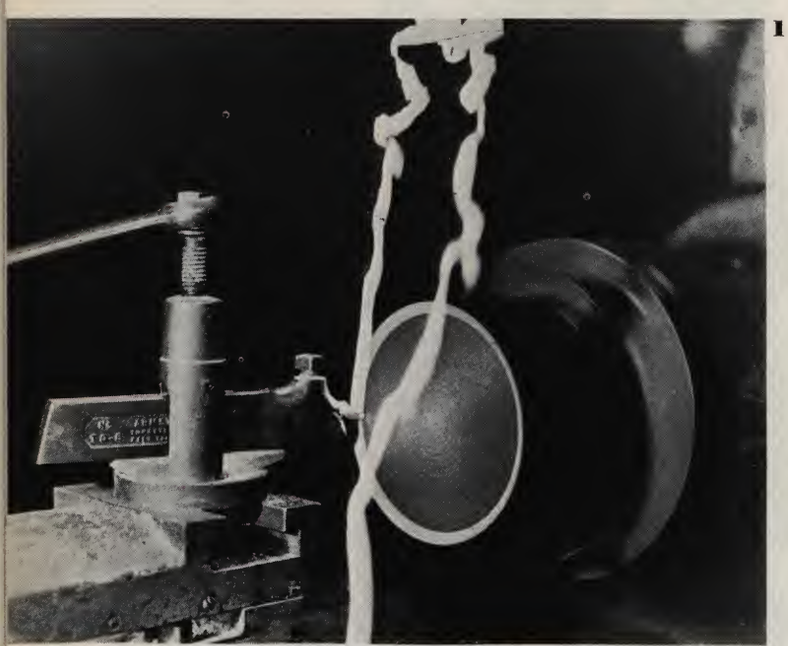
BRIDGEPORT BPM CONNECTICUT

Machining cast resins

IN considering the fabrication of cast phenolic plastics, it is perhaps important at the outset to emphasize the differences between cast and molded plastics.

Cast phenolics are supplied to fabricators or to customers in fully cured rods, sheets, cylinders and special castings which are converted, through fabrication, into finished articles. The special castings approximate as closely as possible the configurations of finished parts, and where they are integral units, such as knife handles, shaving brush handles, pen tapers, etc., it is necessary only to remove the flash, drill holes for the tangs, and polish them before they are assembled with other parts to make the completed units.

Molded plastics, on the other hand, are supplied in powder form to firms equipped with injection or compression molding machinery, and are converted thereby into semi-finished and finished parts.



1



2

Lathe and screw machine production

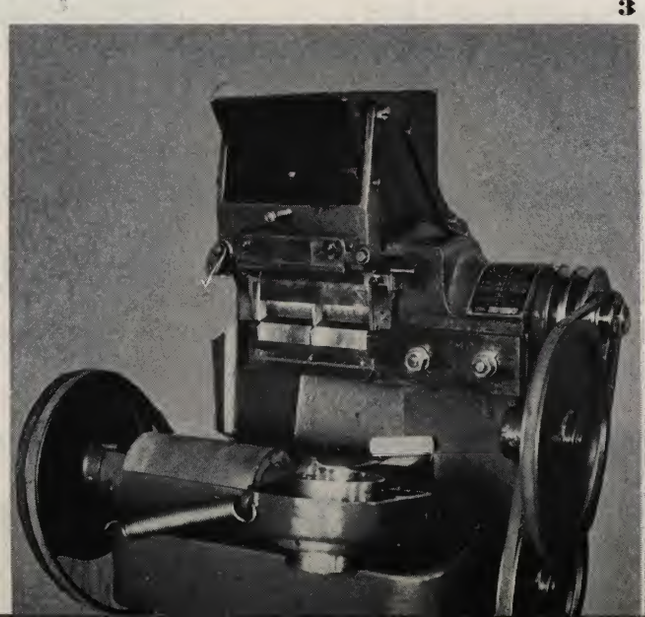
Regular machine shop equipment is used in producing parts from cast plastics. In quantity production of screw machine parts, operations similar to those applied to metals, such as drilling, turning, threading, tapping and milling are performed under conditions involving only differently ground tools, and ranges of feed and speeds adjusted to the material's requirements.

There are few hard and fast rules governing the machining of cast plastics, but it may be said in general that high speeds and light cuts are preferable. Nearly all work is done dry, but coolants of the non-alkaline type may be employed, although rarely required. In producing parts on an automatic screw machine, where the taper common to rod stock may hamper the feed of material, the rods may be had centerless ground to close tolerances and uniform diameter throughout every inch of the entire length.

In turning, tools are sharpened very much as for brass work. There should be plenty of clearance, 18 to 20 deg., and a slightly negative or zero rake is desirable. The tool should be set at right angles to, or one or two degrees above the center of the material. Cutting edges should be in condition to produce long ribbon shavings. Tool honing is of advantage for the smoothest cuts. Special grades of tool materials are not required although many hard bronze tools are employed. These have an advantage in that they may be filed without removal from the holders. Stellite-cemented carbide or

1—Trimming phenolic casting to required rough dimension is accomplished by turning. 2—Fancy and intricate shapes of varied size are easily and readily made on a conventional lathe. Machine steel and turret lathes are used in large production. 3—Automatic, abrasive machines are used for high speed production of small parts such as balls or stones. (Photos, courtesy Catalin Corp.)

3



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4



5

4—Rotary steel cutters fastened to a motor shaft are used for carving. 5—Cast phenolic letters in scroll or of intricate design that is not included in the regular stock forms of castings are jigsawed from sheets in the same manner as wood or soft metal

high speed tools may be used when it is desired to get the longest possible runs without frequent delays for re-sharpening or re-setting the equipment.

Spindle speed in turning operations ranges from about 450 to 6000 r.p.m., depending on the specific work being done and the diameter of the material, and should be regulated to a surface speed of 600 ft. per minute.

In general fabricating practice, the use of large lathes is avoided wherever possible. Through the application of a little ingenuity operations may be reduced to their simplest form and frequently executed on bench lathes or similar light and flexible equipment. Jigs are of course invaluable in securing fast and accurate production. With tools properly set, sharpened and fed, screw machine or lathe production may go directly into the first stage of the hand-polishing or tumbling operation.

Automatic abrasive forming machines

Because of the impracticability of casting rods longer than 21 in., production from automatic screw machines has not reached the high figure attainable with metal. The necessity of having the constant attention of an operator to feed the rods into the machine has acted to reduce the production per operator.

To overcome this feature in automatic screw machine work, forming machines are being widely substituted for screw machines. In the production of balls, beads and what were formerly turned pieces, these machines have no peer. They comprise two stone wheels from 6 in. to 10 in. in length and 4 in. to 6 in. in diameter operating in opposite directions and parallel to each other. One stone acts as a stop and guide and has a flat surface, and the other is formed with diamond cutters to multiples of the shape of the part and acts as a cutter. The rods are cut to convenient lengths, placed in a hopper and automatically dropped between the stones. A flood of water removes the cuttings, cools the material and keeps the stone surfaces from clogging. With the smooth surfaced wheel keeping the material in place and slowly turning it against and toward the cutting wheel, which revolves at a much higher speed, the rods are quickly and smoothly formed into from 3 to 15 or more units, depending on their length and that of the rod.

In this manner, for example, from 350 $1\frac{1}{2}$-in. diameter balls to 10,000 $\frac{3}{16}$-in. diameter balls can be produced per hour. Uniformly accurate and smooth production is had with no shut down for tool honing or re-setting.

Drilling and carving

In drilling small holes, drill speeds of about 2800 to 12,000 r.p.m. are commonly used. Drills of $\frac{1}{4}$-in. diameter and over should have large flutes for efficient material removal, and cutting edges should be ground with a negative rake.

Turned parts requiring center holes are drilled by means of a turret head attachment, while being turned, whereas odd shaped castings or parts are easily drilled with the usual type of high speed vertical drill.

The material may be easily tapped on vertical or horizontal tapping machines. Standard taps are used, and greater strength is obtained by using fairly coarse threads. Tapped holes should be checked with plug gages, as the abrasive action of the material is likely to cause wear.

Carving is done with rotary steel cutters fastened to the end of a small motor shaft. Cutters average about 1 in. in diameter and rotate at about 2200 r.p.m. The number of teeth in one-inch cutters is usually 20 to 36.

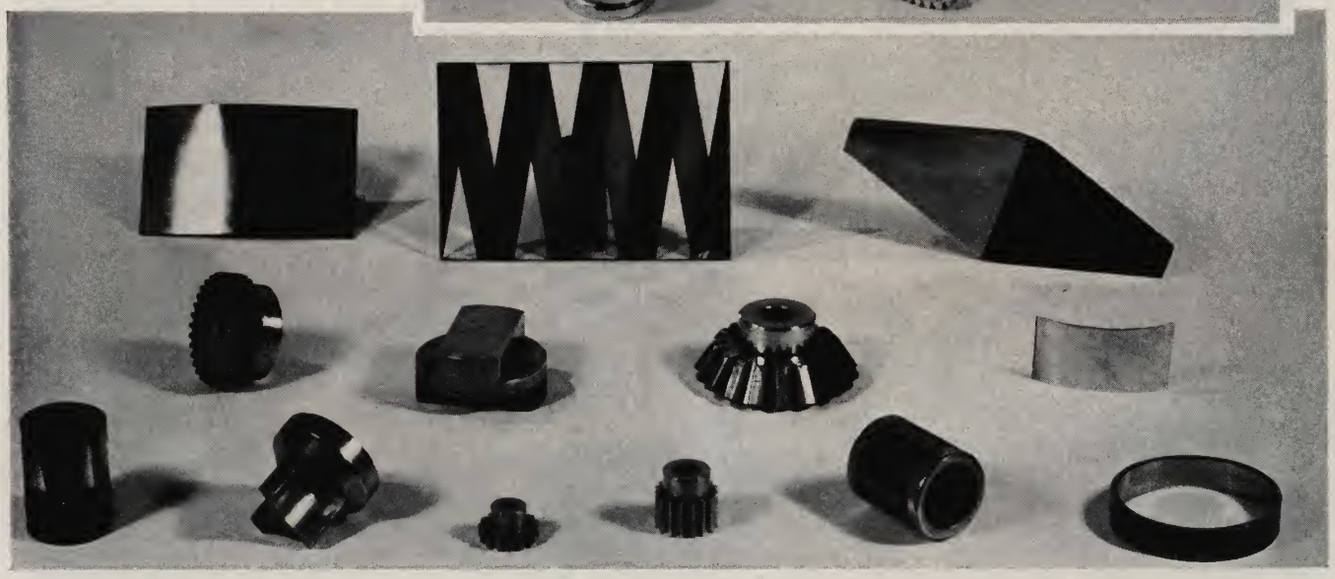
Cutting and sawing

Of all the machines used for cut-off purposes, those employing abrasive cut-off wheels are most widely used. They involve a high speed spindle, to which is fastened the abrasive disk, mounted on a swinging arm on the other end of which is the motor. The weight of the motor acts as a counter-balance, and permits the operator to feed the wheel down into the material. The latter is held in place by hand against adjustable stops governing the angle of the cut and the thickness of the blank. A

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There is a definite trend in the industrial as well as the novelty fields toward bright chromium and other metal finishes. By the Metaplast process complicated shapes which could not be economically made of metal, can be molded and given an attractive metal finish. Metaplated plastics are strong, light in weight, and resist denting to a greater extent than thin metal sections.

The appealing tones of bright and satin finish gold, silver, and other precious metals add glamour to any item. Attractive Metaplated articles have the rich effect of metal, yet are extremely light in weight and pleasant to touch. De luxe finishes for everyday articles can be obtained by transforming plain colored plastics by the Metaplast process. Metaplated plastic novelties have the appearance of expensive jewelry items and can be sold at popular prices heretofore impossible.

METAPLAST CORPORATION

244 FIFTH AVENUE — NEW YORK CITY

flood of water on the material prevents scorching and produces a smooth easily polished cut with a minimum of waste. This equipment is used extensively for cutting button blanks and handles from profile shaped rods or slabs.

Most of the cutting disks range from 0.020 in. to 1/16 in. in thickness and from 5 in. to 20 in. in diameter. The spindle speeds range from 3500 to 6000 r.p.m., depending on the diameter of the cutting disks. The rate at which blanks are produced varies with their diameter, ranging from 20 per min. upward to 250 or more.

There is available a hand-operated adaptation of the abrasive forming machine for multiple cutting of round and rectangular shaped rods. This machine will cut simultaneously 40 poker chips, 1 1/2 in. diameter by 1/8 in. thick, at a rate of 10,000 per hour. Rectangular shapes, such as mah jong blocks, dominoes, cutlery handles, etc., can be cut ten times faster than with a single blade cutting machine.

Sawing is done at 1200 to 1300 ft. per min. or above. The saw may be circular, jig or band type, and the set of the teeth should be just sufficient to permit proper clearance. Best finish results are obtained on a band saw with 14 or 15 teeth per inch. On a jig-saw, the generally accepted blade is a No. 3 jeweler's blade with 22 teeth to the inch for intricate work, and a No. 4 or No. 5 blade for production or stacked work.

Polishing

Cut surfaces have a dull frosted appearance which is easily polished by hand or tumbling processes.

Hand polishing is usually done on a 2 h.p. double-spindle buffing lathe equipped with unstitched muslin disks 12 in. to 14 in. in diameter, which run at a speed of 1500 r.p.m. However, any common buffing head with the above wheel equipment may be employed.

The first operation is ashing. This is done with a mixture of 00 pumice and water, mixed to a thick paste, which is applied frequently and generously to the wheel and the work. After a few brisk rubs the parts should be thoroughly rinsed in water to remove all trace of pumice. Special polishing compounds or tripoli is applied to the wheel, and the part is then rubbed briskly.

To harden the finish and remove any excess polish which may have a tendency to retain finger marks, a final buffing operation on a dry, clean wheel is used.

In finishing comparatively small articles or large production runs, hand polishing is obviously expensive and slow. Cast phenolics lend themselves admirably to tumbling operations, but because of the presence of important variables concerning the finish of the part, its size, and the degree of polish to be obtained, it is impractical to set forth here formulas covering tumbling operations which can be universally used.

Manufacturers of tumbling barrels and tumble-polishing compounds have a service in connection with their activities whereby experimental runs of any type of polishing may be made, and exact formulas covering the proper performance of these operations are submitted by them to the customer, thus obtaining a scientifically correct and uniform finish to tumble-polished articles.

Sanding

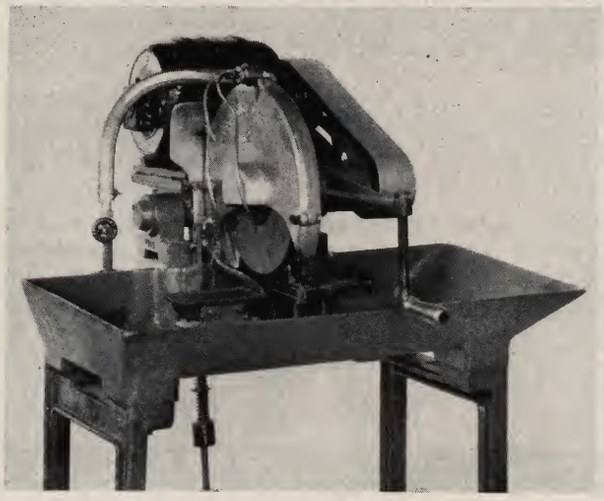
It is seldom necessary to resort to "sanding" well-machined pieces, but sanding can be done on flat or convex surfaces with garnet, silicon carbide or sandpaper, which can be used in belt form or in rotating disks. The finer the paper and the slower the cutting, the less pronounced are the abrasive marks. Facets and other surfaces can be cut in this way, but in all cases care must be exercised to avoid over-heating the work, as such "burning" may result in discoloration. The surface speed in sanding plastics is about the same as in wood sanding.

Fastening methods and devices

Manufacturers of cast plastics have developed cements for laminating their products, and specifications covering the types of cement available and instructions for using

6—Abrasive cut-off machine for slicing rods, tubes and blanks of cast resin with minimum waste. 7—Dry tumbling is an effective economical method for finishing machined cast parts

6



7



Knowing the Answers



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8



9

8—Machine for fastening with drive screws or self-tapping screws, handles, knobs and hinges to all kinds of parts. 9—Sanding wheel with bench in position for rapid finishing of flat or convex surfaces

them may be quickly had upon application. In general, it may be said that the cements are simply liquid resins which may be hardened either by the introduction of an acid accelerator or by the application of heat, or by a combination of both.

Among their many applications, cast phenolics count handles and knobs one of the most popular, and the problem of permanently fastening the handles or knobs to metal shanks immediately presents itself. However, with a little experimenting a satisfactory solution is quickly obtained. In the assembly of cutlery handles the hole to receive the tang is drilled about .006 in. smaller than the diameter of the tang. The handle is then immersed to the depth of the hole in water, heated to 180 deg. F., and allowed to remain long enough for the immersed part to become thoroughly heated.

While still hot the tang may be easily pushed (but not forced) into the hole and allowed to cool. A permanent grip which will not twist or slip is assured if the tang is knurled. This same principle applies to all shrink-fit assemblies whether tangs, inserts or bushings are used.

Although the manufacturers' cements are the best adhesive to use in laminating cast phenolics, it frequently becomes necessary to fasten metal and other non-porous materials to cast phenolics, in which case cementing is usually impractical.

Several methods of accomplishing these operations are available. In the manufacture of jewelry various metal findings such as clips, catches and pins must be firmly fastened to the material. Most manufacturers of these articles can supply them stamped with small pointed studs which may be easily forced into the material when it is heated to a temperature of about 125 deg. F. on a hot plate adjacent to the hand or foot press. When the material cools and hardens a permanent grip is assured.

In other instances small hinges, handles, knobs and similar parts are to be fastened to the material. Here drive screws or self-tapping screws may be used to advantage. A hole usually one drill size smaller than the screw is drilled in the material and the handle or knob held in place by driving the screw into the hole. It twists and taps the hole as it enters and once in place cannot easily be removed.

Where the assembly calls for machine screws which on occasion are to be removed, the material may be drilled and tapped much the same as metal, a coarse thread being recommended to reduce the possibility of their being stripped.

Die cutting

Because the material may be secured in a wide variety of special profile-shaped rods from which blanks of any desired thickness may be cut or sliced, it is rarely economical to die cut sheet stock. However, when production requirements are too high for jig sawing, and too low to warrant the investment in dipping arbors, die cutting offers a practical solution.

Sheets thicker than $^3/_{16}$ in. cannot be die cut, but for stock of that dimension or thinner, satisfactory results may be obtained by heating the material to about 150 deg. F. and stamping with a steel rule die.

Forming

In general fabricating practice, it is often necessary to curve or shape sheet and rod stock to various radii. Providing the radius is not less than $^1/_2$ in., depending on the thickness of the material, this can be readily accomplished by heating the material to about 180 deg. F. in hot water until it is of the same temperature all the way through, and then placing it over or about the form and allowing to cool. Inasmuch as hot water does not harm the finish, it is advisable to polish the material before forming. It will be noted that the material will expand while at this high temperature, but will return to its original dimensions when fully cooled.

Cast phenolic resins lend themselves to varied decorative treatment such as printing, roll leaf stamping, engraving, inlays, and metal plating which are described in a chapter devoted to these subjects elsewhere in this issue. (See *Applied Decoration*, page 256.)

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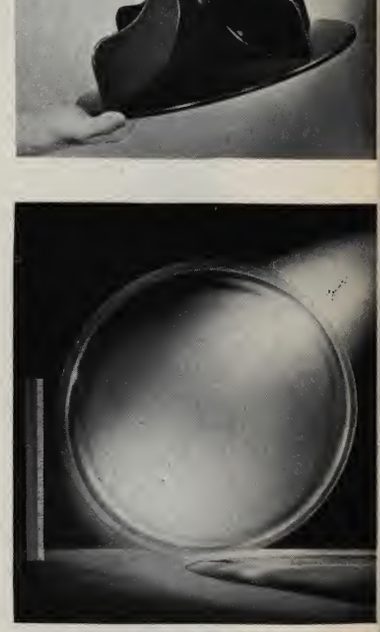
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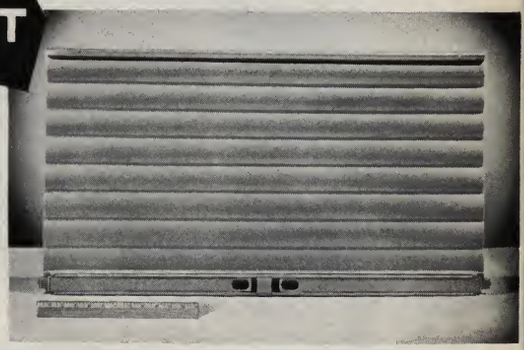
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To install the largest compression press used exclusively for moulding of plastic parts to customers' specifications.

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To develop Tenite Window Shades used on Greyhound Busses. Eclipse was first to produce this unit — the largest plastic part ever moulded.

Eclipse MOULDED PRODUCTS COMPANY

5151 North Thirty-Second Street, Milwaukee, Wisconsin

CHICAGO . . . DETROIT . . . NEW YORK . . . CLEVELAND . . . ST. LOUIS

MOULDERS OF — Resinox . . . Tenite . . . Plaskon . . . Durez . . . Lucite . . . Beetle . . . Bakelite . . . Lumarith Polystyrene . . . and other materials.

Fabricating pyroxylin

THE foundation of the plastics industry can justly be said to have been laid with the experiments of John Wesley Hyatt in the United States and Alexander Parkes in England, who almost simultaneously demonstrated that a useful artificial material could be made with a pyroxylin base. Almost as old as the plastic itself are many of its applications and methods of fabrication. Probably one of the most interesting collections of the early developments of pyroxylin can be found at the Kensington Museum in London, England. There, on display, are specimens dating from 1855 and onwards, with finished products anticipating many of the present day uses of cellulose nitrate plastics. (See page 45)

Pyroxylin plastics have come a long way since the early work of the pioneers. Methods of fabrication have been increased and improved, and thousands of new applications developed. In spite of the encroachments of numerous plastics of other types, there was consumed in the United States alone some 10,600,000 lbs. of pyroxylin plastics in 1938. Similar material is made in large quantities in Europe and Japan.

These pyroxylin plastics are essentially cellulose nitrates and camphor, together with suitable coloring ingredients. They are thermoplastic and are produced in the forms of sheets, rods and tubes. They have established and held their place by virtue of a unique combination of useful properties. Pyroxylin plastics may be made in an almost infinite variety of single and combined colors, ranging from a practically colorless transparent through translucent to opaque, possessing beauty in their own right or through the simulation of expensive natural substances such as ivory, tortoise shell, fine leathers, amber and mother-of-pearl. They are light in weight, strong and tough, durable and readily adapted to various methods of fabrication, all properties contributing to wide-spread use.

Fashioning the numerous articles which are made from pyroxylin plastics requires a diversity of methods of fabrication. Practically all, however, are merely variations of the two fundamental methods of shaping to which these plastics are particularly well suited, namely, by machining and by the use of heat and pressure.

By machining, when handled with a reasonable degree of care and precaution, pyroxylin plastics can be turned, sawed, drilled, tapped and cut more easily than wood or metal. The material has no grain like that of wood, but machines equally well in either direction, and being softer than metal, can be worked at a high rate of speed. Its toughness tends to eliminate cracking or splitting and makes possible rapid machining, either with the hand tools of the home mechanic or the high speed automatic and semi-automatic equipment of the large factory. Some of the examples of these operations

All photos, courtesy Optical Products Corp.

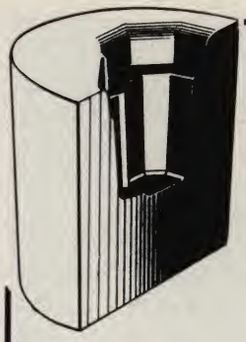
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2



1—Optical frames and other articles machined from pyroxylin require precision lathe turning. 2—The frazing operation corrects irregularities by adept use of rapidly revolving tools and sandstone wheels. Pyroxylin plastics may be fabricated by a variety of methods such as machining, engraving, carving, swaging, blowing and die pressing.

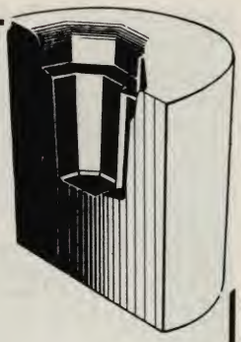


HOBALITE

for

HOBBED MOLD DIES

A GOOD SINKING IN 1935



TODAY

PERFECT CAVITIES ARE HOBBED

12″ x 6″ x 2½″ Deep—10″ Dia. x 3″ Deep

The plastic molding industry grows in leaps and bounds. We had to improve Hobalite at that pace. March 1939, closed a long period of research and checking under actual hobbing conditions, proving we had improved hobability, reduced porosity, and improved reaction to heat treatment.

The hobbed cavities in Hobalite have that perfect finish which gives high lustre to the molded part. Properly case-hardened and heat treated it withstands a pressure of **82 TONS PER SQUARE INCH.**

COBALTCROM PRK33

For

MACHINED MOLD DIES

This highly alloyed tool steel contains nine outstanding characteristics: Still Air Hardening, Minimum Deformation, High Hardness, Non Scaling, High Compressive Value, High Abrasive Resistance, Heat and Corrosion Resisting, Very High Polish, Grinds Super Keen. Each characteristic is directly applicable to a fine and high productive Plastic Mold Die Cavity.

We help your costs to a moderate total by casting PRK, leaving a minimum of machining, and frequently only a grinding operation for the cavity finish.

HOB STEELS

NEOR HARGUS or BRAND H DO-IT

Steel for hobs must contain high compressive strength, high hardness, high polish, minimum of change of size and deformation in heat treating.

NEOR and HARGUS Brand H both contain these features, but if pressure develops per inch in the maximum range, namely, 220 tons, NEOR is recommendation No. 1, owing to its deeper hardening, and HARGUS Brand H is No. 2.

When cavities are narrow, long and deep, the above physicals become secondary to a high elastic strength, so in that class of hobs we recommend DO-IT.

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Calumet, Mich.



Powdered pumice used in a rapidly revolving brush wheel removes scratches and gives a high luster to finished pyroxylin products

can be found in the fabrication of familiar articles. Many fountain pen barrels and caps are turned out rapidly and accurately by automatic turret lathes. In the manufacture of pyroxylin combs, sawing out the material between the teeth is still a familiar sight. At the toothbrush fabricator's plant, the pyroxylin brush blocks are rapidly drilled and bristles installed and fastened into the holes by automatic machinery.

There are also many other methods of fabricating pyroxylin plastics closely allied to machining. For example, scales for slide rules and rulers are rapidly and accurately engraved by automatic machinery. Huge blanking presses equipped with dies are employed for forming blanks for use in making brush handles and backs, combs and numerous other articles. Carving is frequently practiced in adding a design to a powder box or other articles and where desired, a high polish is given the finished product by the use of a rapidly rotating rag wheel supplied with fine abrasives.

The fact that pyroxylin plastics are softened by heat, can be shaped while thus softened, and then regain their rigidity when cooled, forms the basis for the operations of swaging, blowing, and die-pressing. The operation of swaging or forming, as it is sometimes termed, is well illustrated in the making of a soap box. A rectangular blank of pyroxylin sheeting becomes pliable under heat and is then stretched by the closing of a metal mold. Preheating is accomplished by means of boiling water, a steam table or an electric plate. The mold is ordinarily unheated and is closed rapidly in order to shape the material before it loses its plasticity from contact with the cool metal. When the article has cooled to the point where it can be removed without distortion, it is thrown into water to complete its cooling.

Analogous to swaging is the operation of blowing which makes use of the material in sheet form for the fabrication of such familiar articles as floating toys and ping pong balls. By this method, two thin sheets of plastic are preheated and placed between two preheated metal plates containing matched half cavities. The plates are placed under hydraulic pressure and a tiny nozzle is inserted between the sheets through a groove in one plate. Hot air or steam is then forced between the sheets at all points where they are not held in contact by the faces of the mold, causing the sheets to belly out and take the form of the cavities. The whole system is then chilled by dipping in cold water and the finished article removed.

A combination of swaging and blowing is applied to the formation of certain articles which cannot be shaped by swaging alone. One example is a circular container with shoulders, such as a fancy powder box. In this case, most of the vertical stretching is effected by a perforated plunger, after which steam, entering through the perforations, swells the sheet out against the concave mold, which is split to allow the removal of the article. Swaging and blowing are thus used in the production of thin walled articles.

Die-pressing, still another method, is applied to massive articles, and involves merely the change in configuration of a massive pyroxylin blank in a suitable size and in a simple shape approximating as nearly as convenient, that of the finished article. Thus toothbrush handles are made from pieces of sheeting, cut to strips of proper length and width. Thus, too, are combs pressed from rectangular blanks of the plastic. In die-pressing, two types of dies are employed, one, the flow type, in which the excess material flows out through a split in the die, and the second, the confining type, which receives the exact volume of material, all of which goes into the article being die-pressed. In die-pressing, the blank is also preheated. The die must usually be heated and then cooled, although a few articles permit the use of a cool die.

Another method of working pyroxylin plastics which requires the softening of the material, is embossing. To obtain, for example, a radio panel by embossing, a sheet of pyroxylin is placed beneath a metal sheet containing the desired surface design. To impart the design to the plastic sheet, heat and pressure are applied. After the proper interval has elapsed, the sheets are cooled and the plastic containing the desired design is stripped from the metal sheet.

Another means of softening pyroxylin is by submersion in a bath of acetone and water or exposing to acetone vapors. The acetone is a solvent and therefore softens the pyroxylin. This method is employed in covering such items as women's shoe heels and clothes hamper tops. A pyroxylin blank of the proper size and shape is first softened and then stretched over the wooden heel or cover and cemented at the edges. The result is a smooth, durable and scuffless covering.

By these main techniques and by their slight variations to suit the particular job, are produced the multitude of articles to which pyroxylin plastics impart utility, durability and the beauty of color and pattern inherent in the material. Though it is a veteran in the field, modern designers, familiar with the capabilities of pyroxylin, are constantly developing new applications, thus assuring the continuance of pyroxylin as one of the mainstays in the plastics industry.



Not Easy...
But not *Too Tough!*







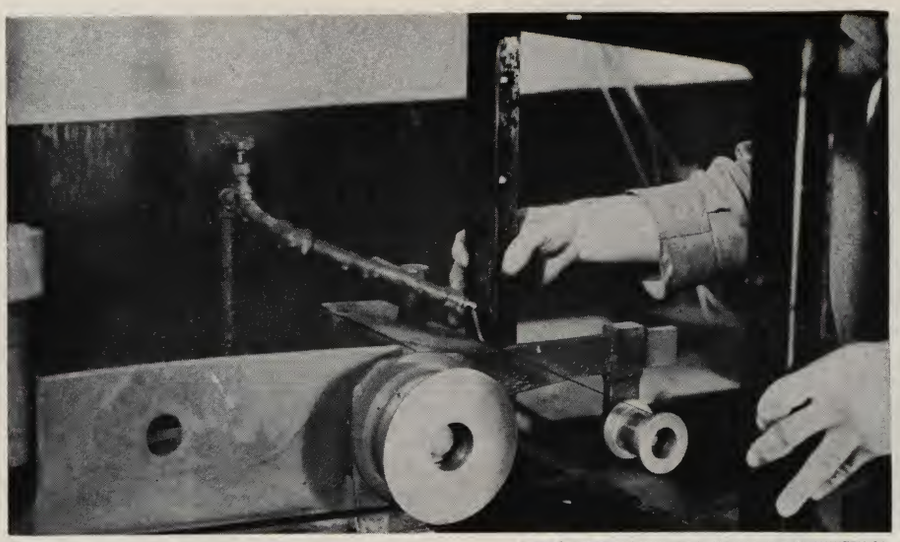
The molded housing shown is a "fussy" job. Takes a lot of care and concentration and experience to turn it out to meet the specifications. As you can see, the undercutting and holes (which must be kept in alignment) are liable to give a molder more than a few headaches.

Our 27 years of experience in molding and our modern, high-speed injection and compression presses are at your service. We mold in Bakelite, Durez, Makalot; Beetle, Plaskon; Fiberloid, Lumarith, Plastacele and Tenite; Lucite and Polystyrene; and shellac compounds.

T. F. BUTTERFIELD, Inc.

MANUFACTURERS OF MOLDED INSULATION

NAUGATUCK **CONN.**





1 PHOTOS, COURTESY MINNESOTA MINING AND MACHINERY CO. 2

1—Narrow sanding belt of Wetordry Tri-M-ite Cloth is used to remove flash from outside and inside edges of phenolic refrigerator doors. 2—This Porter-Cable Wet-r-Dry Grinder may be adapted to either wet or dry finishing depending upon class of material and finish desired. Speed may be varied, coarser or finer abrasive used as required. Operation can be altered as required

Finishing methods and equipment

THE specification of equipments for the finishing of plastic materials can best be made after an analysis of the method by which the part has been produced, its physical characteristics and size, and the number of pieces. Numerous types of machines have been employed by custom molders and fabricators for working with the plastic materials, and many of these have been standardized upon. This has been possible because the nature of the finishing operations does not vary to a great extent, permitting the installation of equipment which will be quite flexible as far as its utility is concerned. Manufacturers have recognized the advantages of such investments, and each passing year witnesses increasing attention being given to these problems, because only through the application of the proper finishing technique will improved quality be realized.

In the following paragraphs a review is undertaken of the nature and type of surface defects that appear on plastic materials, following which recommendations are made for overcoming these problems.

Compression molded parts

The surface which is developed upon a molded article depends upon the degree of polish which was applied to the molding surface. Under the correct molding conditions and the proper molding powders, articles may be removed from the mold with a high degree of luster and uniformity, possessing surfaces which require no further finishing. However, due to the ramifications of molding this acceptable surface is not always attained. Besides, the mold itself may not have undergone a very careful polishing (which may be the case for an experimental cavity). Removal of the *orange-peel* skin and the restoration of a high gloss are possible through low cost finishing operations.

Flash lines are, of course, prevalent in all compression-molded articles where there is a division between sections of the mold construction. They are due to the slightly imperfect mating of the mold sections, which may be .001 in. or less. They are always markedly present at that portion of the mold where excess molding material is permitted to *spill-out*. Every mold designer makes an effort to keep this flash line as small and inconspicuous as possible for the purpose of reducing the extent of the finishing operations. Removal of the flash line becomes an increasingly difficult problem as the mold wears through continued operation and the flash lines grow thicker—as much as .032 in. thick in some cases. The ability to keep flash lines to a minimum is one of the arguments advanced for transfer molds, which are clamped tightly together before the molding material is introduced. This, of course, is a desirable feature, though the entrance sprues from the plasticizing chamber are additional points which need attention.

Flash lines which are concealed from the public view may require nothing more than a simple hand filing operation. On the other hand, if they appear in the middle of some well-rounded or smooth surface, their

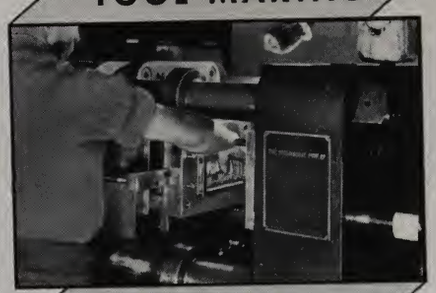
Sinko
PRECISION
MOLDING SERVICE



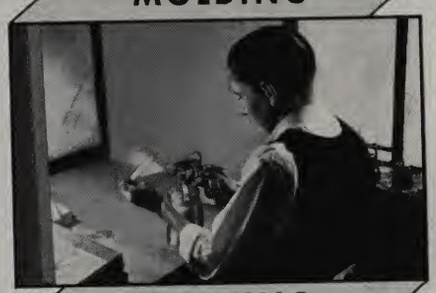
DESIGNING



TOOL MAKING



MOLDING



SPRAYING



FINISHING
IN
METALS and THERMOPLASTICS



SPEEDY INJECTION MOLDING AS WE PRODUCE IT MAY PROVE MORE EFFICIENT AND ECONOMICAL FOR YOU

Manufacturers in rapidly increasing numbers are consulting our skillful engineers on molding problems. For, some of the most intricate jobs in the history of injection molding have been designed and produced by our capable staff. Both the top award and an honorable mention were given to SINKO moldings in the 1940 Modern Plastics competition!

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removal entails diligent care. Even so, it is always difficult to remove the slight trace of flow marks which invariably appears under these circumstances, and even though the surface is rendered perfectly smooth, a slight imperfection will usually be noted. The heavier the flash line, the more this will become apparent. Wherever the practice may be followed without adversely affecting the design or utility of the piece, an effort should be made to embody some provisions in the nature of ribs or other expedients for concealing potential flash lines.

Injection molded parts

The gates or entrance sprues are those particular areas on injection molded pieces which require finishing operations. While this area is usually small in relation to the whole surface, the finishing operation may require a longer period of time than for an equivalent phenolic or urea piece, because the cellulose acetate is a tougher material. While the practice is often followed to tumble many of these parts, hand filing of the gate or sprue entrance may be all that is required. As for compression-molded articles, this procedure is largely determined by the ultimate purpose of the article and the significance of the smoothly finished surface. Injection molds are clamped tightly together before the material is injected, thus minimizing the amount of flash which may otherwise appear at the lines of separation between the sections of the mold. In many cases when the molds are new these lines are practically indistinguishable.

From the standpoint of the finishing operation, it is naturally desirable to keep the injection gate or sprue to the article as small as possible. While the sprues are, in fact, tapered off at the entrance to the mold, this cannot be carried out too far or the mold will never fill out to completion during the cycle of operations. In many cases, more than one injection sprue will be necessary.

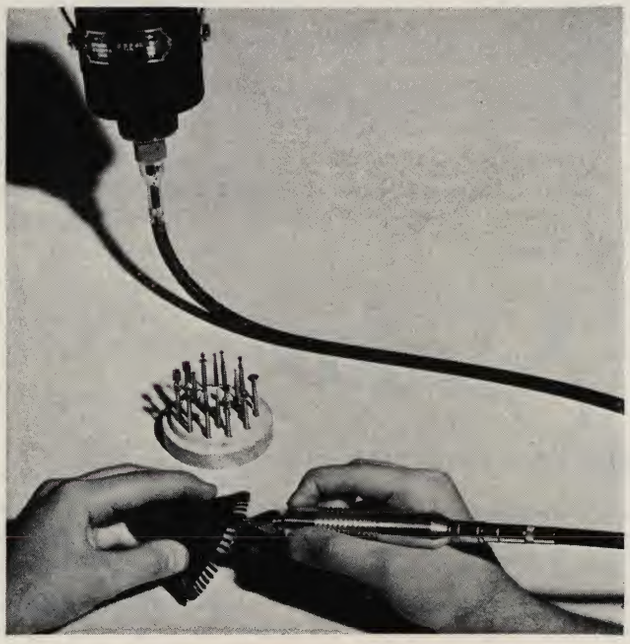
Machined surfaces

The restoration of smoothly finished surfaces to machined thermosetting and thermoplastic objects entails numerous problems based not only upon various machining operations, but also on material differences. From descriptions noted below, various procedures may be followed for cast phenolics, depending upon the size of the article. When pieces are small and machined from some rod or tubular member of a plastic material such as casein, cast phenolic, or a thermoplastic material, tumbling operations may often be employed for finishing the work, and removing the tool marks. Larger pieces which may have been engraved with some pantograph machine or with a small portable hand grinder may have to be handled upon a buffing wheel.

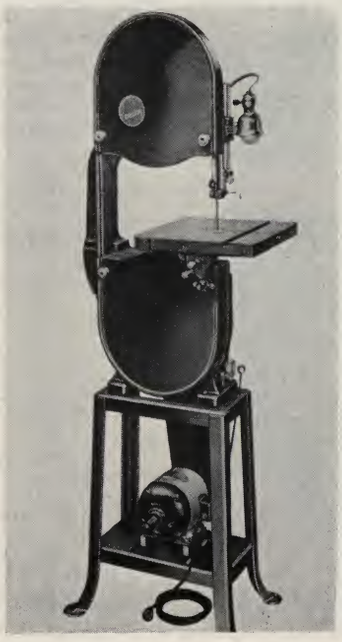
Machining operations are not confined to stock size rods or tubes. Molded pieces sometimes necessitate additional machining to attain certain undercuts or close tolerances which were not possible during molding. Usually a buffing operation would be required to restore the surface, but if the machining is concealed from view in the final assembly, it may be practical to eliminate further finishing.

From a decorative standpoint certain engraving operations with either a pantograph or small portable grinder may be left intact without any attempt to restore the luster, as the rough machining marks of the grinding wheel afford a pleasant contrast to the rest of the surface. This is practiced widely for decorative panels prepared from methyl methacrylate, in which the decorative motif is prepared in three dimensions. Grooves machined by pantograph equipment may be suitable for the application of inlays as by the Chilton process, or for wiping in some decorative lacquers. Excess lacquers are removed from the surface by wiping with a clean cloth and some suitable solvent. *(Please turn to next page)*

3



4



3—"Artco" lightweight flexible shaft grinder can be used with a wide variety of interchangeable polishing tips. 4—Delta 14-in. band saw is ideal for cutting all types of molded, extruded and laminated plastics and metals



Reprint from FORTUNE, October, 1940

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One big reason why Reynolds Molded Plastics add new customers constantly and holds those who have stayed with them year after year is that its production tempo continues, and will continue, its long unbroken rise.

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Now, more than ever, Reynolds customers are assured uninterrupted service . . . a completely dependable, permanent source for better molded plastics.

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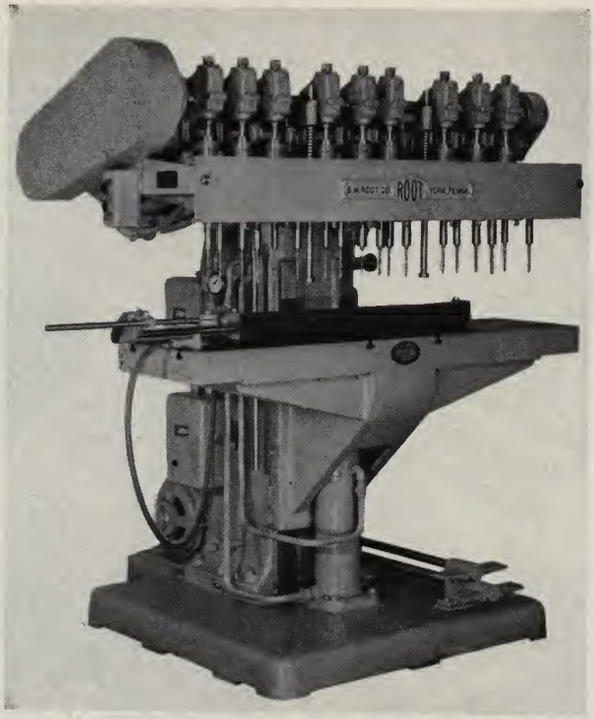
Call in a Reynolds sales engineer who will co-operate with you to work out a profitable plan that will speed both your production and sales.

REYNOLDS MOLDED PLASTICS

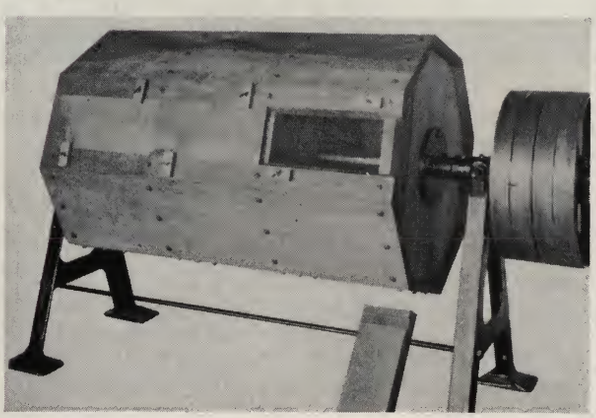
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JACKSON, MICHIGAN, U. S. A.

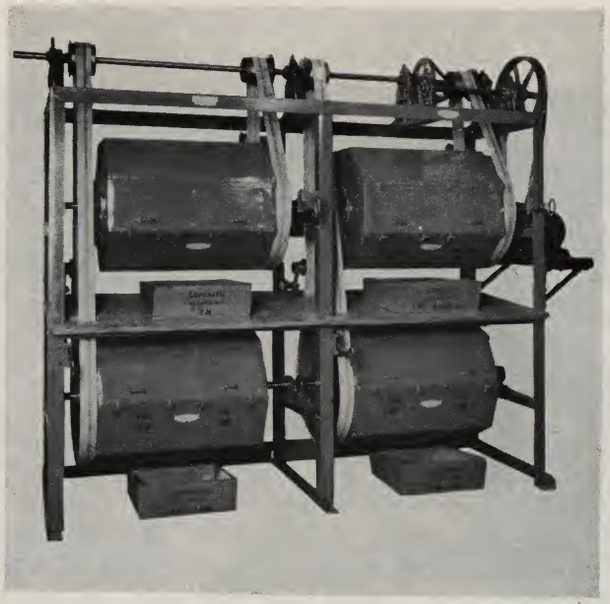




5



6



7

5—Multiple spindle drilling machine by B. M. Root Co. for drilling or taping plastic parts. 6—Belt driven Lupomatic tumbling machine with four barrels, appropriate for tumbling small molded articles which are placed in barrels along with polishing compounds and other agents. 7—Triple-pocket maple tumbling barrel designed by Rudolf R. Siebert for running three separate tumbling operations simultaneously

Cast phenolics

While the majority of cast phenolics are machined in some way, requiring operations for finishing off the tool marks, special handling is required for pieces such as radio cabinets which are finished or molded in one pour. The face or front portions of the radio cabinets are usually located at the top of the lead mold, which is generally filled with an excess of resin. Heavy flash is developed at this surface, requiring prolonged finishing. Further, the same finishing schedule must provide for smoothly rounded edges on the corners of such pieces. The same objection will appear for other objects, and their elimination is distinctly a problem for the finishing operation. These materials will develop a high luster very satisfactorily, and are capable of achieving this either by buffing or tumbling.

Formed or drawn thermoplastics

Important to thermoplastic sheets, particularly the transparent varieties of cellulose esters and methyl methacrylate, are the various finishing operations which are required to produce a smooth uniform surface. For many designs the sheets are drawn or formed in molds or over blocks which are extensive in area. Prepared from wood or plaster of Paris these molding forms are employed because they are simple to make and low in cost. Sheets of thermoplastic materials are preheated before placing them in these simple molds, which will cause the slight imperfections on their surface to appear in the finished sheets. Elimination of these defects by buffing operations are usually imperative, unless an investment is made in a more costly, highly polished mold.

A further defect which must be corrected by the finishing operation is the appearance of fine, parallel lines which were formed when the sheet was sliced from a large slab of the material. These knife marks often reappear during heating and then forming of the plastic material, and are a defect which must be eliminated by ashing and polishing. Extruded or cast sheets do not possess this type of flaw. Drawing, it must be remembered, serves to magnify such defects, and a small inconsequential bubble on the surface of a flat sheet may draw out into a long, tubular blemish. Of course, the formation of internal strains in transparent members cannot be eliminated by the usual finishing methods, though some annealing of the piece may help.

Effect of size and shape

Not only the nature of the defect on the surface of the plastic article will determine the correct finishing procedure, but also the size, volume and complexity of the

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f

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piece are equally important factors. Obviously all pieces may be handled on the buffing wheel, but when any production is involved this may prove uneconomical. If the pieces are small they may be tumbled over one another in a tumbling barrel quite satisfactorily, lowering the unit cost per member, as they are all handled simultaneously. In special instances when the piece is small and still substantial as in the case of molded acetate beads, it is an efficient practice to use a large diameter barrel, so that as much weight of the beads as practical may be used to clean the surfaces effectively and in a shorter period of time. In another recently developed type of finishing device, pieces are cleaned of flash by tumbling them in a vibrating barrel at high speed, throwing the pieces against one another.

However, when the construction of the molded parts is relatively fragile, hand buffing and polishing may have to be employed. Otherwise, parts may chip and break if they were tumbled around at random within the barrel. A further difficulty sometimes makes its appearance when polishing compounds enter small cracks or crevices which are part of the design on the surface of the plastic piece. This is more apt to occur with tumbling, though it could occur with buffing. The problem is to avoid entrapment of material which would be difficult to remove. Some compounds are more satisfactory than others not only from the standpoint of their polishing or cutting down operation, but also because they leave a cleaner surface, requiring less hand work and wiping with a rag.



8

8—Soft cotton and linen buffs and fine abrasives are used to polish acrylic sheet. High grade automobile cleaners and polishes are used to remove minor scratches and to protect surfaces

For the most efficient finishing procedure, experience has shown that when a large number of parts are involved, operations must be broken down into several stages rather than attempt to complete the whole cycle in one operation.

Rough finishing

As outlined in the October 1939 issue of MODERN PLASTICS, page 320, rough finishing operations are designed to remove heavy flash lines, coarse tool marks, and deep surface defects of every description, as well as gates and sprues of injection molded articles. They are also employed distinctly for *cutting-down* purposes, as may be necessary in the fabrication of models for transparent plastic materials in the form of slabs. Typical operation is the preparation of facets on a gem-like model prepared from a plastic material. Correct angles are maintained through suitable mounting jigs. An abrasive sanding belt, such as shown in the illustration on page 244 is one rapid and popular method of removing heavy flash from molded articles. Filing operations with a simple hand file or a small grinding wheel attached to a flexible shaft drive are usually employed for the flash on molded pieces which may be difficult to reach with an abrasive belt. Of course, in these cases, one must depend more upon the skill of the operator to a certain degree, as the amount of material removed by the operator may vary considerably. One must also not be unmindful of the behavior of the various plastics under the influence of coarse abrasives. Compounds such as the ureas and the phenolics may develop small cracks or check marks adjacent to the edges of the flash, where such rough finishing operations are usually necessary. If this is liable to affect the life or appearance of the article, at least a further buffing or its equivalent should be given to the piece so as to flow over the rough spots by the heat created on the surface of the piece during the finishing operation.

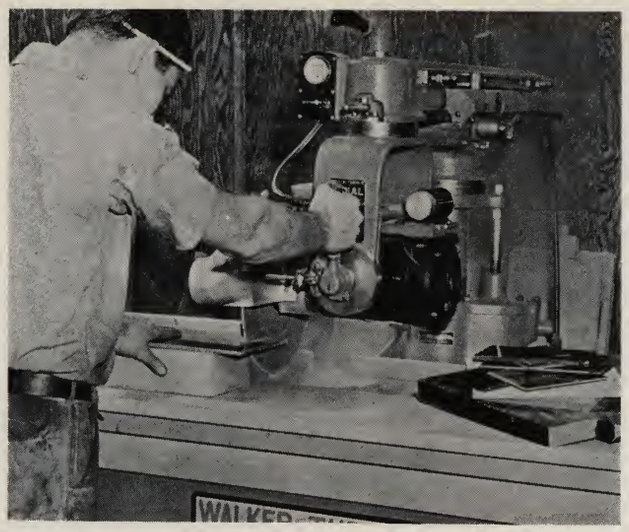
On the other hand, thermoplastic materials, particularly the cellulose esters, may burn on the surface very readily if the roughing or cutting operations take place too rapidly. On a buffing wheel the work must be moved about rapidly in order to avoid developing a localized heating which will mar the finish. The operator must not exert too great a pressure on the wheel or the work may be permanently ruined. Particular care is necessary for transparent plastic sheets which require ashing or sanding. In some cases a light sanding operation on the sheet with a block of wood faced with a crocus cloth will prove a simple expedient. The slow speed of a hand operation will not cause burning on the

To work toward a worthwhile goal is COMMENDABLE.

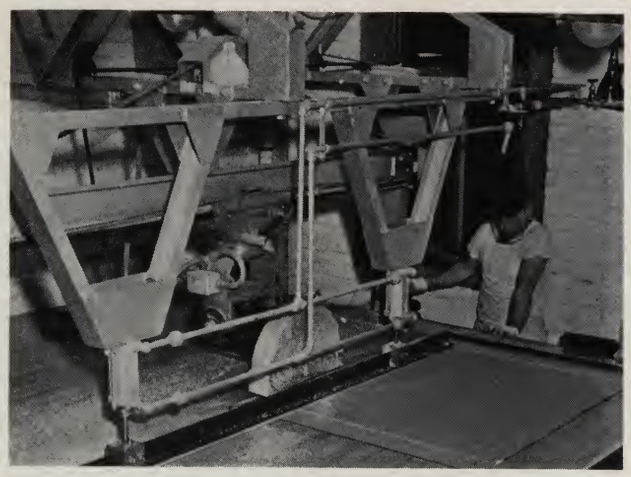
To reach that goal, fairly and honorably is an ACHIEVEMENT.

This is our belief and those whom we have the privilege of serving can best measure our sincerity.

CONSOLIDATED MOLDED
PRODUCTS CORPORATION
Scranton, Pa.



9



10

9—Radial saw for cutting plastic sheet, rods or tubes. The machine cross-cuts or rips at both simple and compound angles. 10—Specially designed for trimming large flat sheets of methyl methacrylate this saw is driven by a geared motor hung on a yoke. Stock is held in place by a compressed air-operated hold-down clamp. (Photos, courtesy Walker-Turner Co. Inc.)

surface on the sheet. Likewise, rough tumbling operations have been developed by the manufacturers of tumbling equipment for the removal of heavy flash and tool marks. In some cases, the pieces may be tumbled with wooden pegs or burnishing balls when the flash must be removed. Longer periods of time are required for the usually tougher thermoplastic materials. A further control is possible by regulating the speed of tumbling though care must be exercised to avoid developing excess heat through friction. Dry tumbling operations will suffice for this type of operation, where heavy flash or sprue marks must be removed.

When machining has left coarse tool marks, it is sometimes advisable to employ a wet tumbling process. This is practiced frequently for cast phenolic pieces and machined ornaments. Pumice and a suitable moist vehicle are employed to finish the surfaces by tumbling. A good mat finish may be obtained after about one hour's running time. As the screen size of the pumice is reduced, longer periods of tumbling will be required. Of course, after this operation, pieces will have to be washed in order to remove traces of dirt and pumice. The tumbling barrels are mounted with sufficient clearance from the floor to permit a receptacle basket to be placed underneath for the removal of the articles after screening. Where space is a problem the barrels may be mounted in tandem, and driven by an electric motor. However, dry tumbling usually proves satisfactory for most rough finishing jobs, and, though longer runs of 3 to 4 hours at 30 to 40 r.p.m. may be required, will not require as expensive a unit. Leading manufacturers of tumbling equipments maintain consulting service for such work.

Polishing operations

After the rough finishing operations, the plastic pieces may require further polishing to attain their natural luster. If articles are being handled which have been molded in a mold that was not polished, polishing outside becomes a foregone conclusion, because much of the attractiveness of molded plastics is due to the high luster which they are capable of developing upon their surface. Small articles may be tumbled satisfactorily, in some cases first requiring a tripoli composition or a chalk abrasive in the tumbling barrel, depending upon the amount of polishing required on the surface. This may be followed by wax polishing in which carnauba and beeswax dissolved in turpentine are poured over articles and wooden pegs in the barrel. A good gloss should be developed by this last procedure. In many examples, the wax tumbling will suffice, though tumbling in a fine abrasive prior is desirable if the piece has been rough finished. This will materially reduce the time required. Removal of abrasives or wooden pegs is accomplished by screening, leaving the glossy finished plastic pieces.

As pointed out above, when the articles attain sizable proportions it would not be practical to tumble them and buffing becomes imperative. While this is essentially a hand operation, much can be done to expedite matters by suitable jigs for mounting purposes and suitable provisions for the flow of molded pieces to and from the buffing wheel. As in the case of tumbling, a light cutting-down operation is usually followed by a coloring operation in which the luster of the surface is developed and final defects eliminated. Buffs are not usually stitched, leaving them readily flexible and capable of deforming easily under pressure from the work, enabling pockets and recesses to be reached by the buffing wheel. The buffs may be built up of one spacer alternating with one buff to reduce their hardness. It is the practice of custom molders to mount buffing machines and tumbling barrels in one room, well equipped with dust collectors to remove the fine powders. The tumbling or buffing usually follows molding, machining, drilling, engraving or wiping-in enamels, so that as few people as possible handle the articles after finishing. They may then be sent to inspection where the finish as well as tolerances and other features are checked. Fingerprints which in-



Come to the House Experience built

Tell us what your problem is. We'll work it out. Then, we'll turn it out — on time and in whatever quantities needed.

It will be molded to your exact specifications — from precision molds designed by us for maximum operating efficiency and to produce finest quality.

It will be made of the right plastic for the purpose — by a shop that knows the properties of *all* the plastics.

It will be molded by the correct mechanical method — compression, injection, or extrusion.

It will be handled with greatest efficiency by a factory new in equipment, operated under ideal conditions.

Above all else, it will be supervised and produced by men who know the plastic molding business from A to Z — men who not only know what to do, but what not to do.

And you'll be in excellent company — numbered among some of the finest names in American industry.

There's never a lull in production — our customers see to it that we're always busy. They like Michigan's way of handling their jobs — we are sure you will, too.

Compression, Injection and Extrusion Methods.

CUSTOM M MOLDERS

MICHIGAN MOLDED PLASTICS, INC.

Dexter, Michigan



advertently appear at this stage are wiped off with a clean rag before shipping.

With large sizes of methyl methacrylate now being manufactured to meet a diversity of applications including their important use in airplane, methods of cutting them to size have had to be developed. One manufacturer of motor-operated radial saws cooperating with a material supplier engineered an excellent solution to the problem. To hold large sheets securely in place and cut over wide areas to very close dimensions they used a compressed-air actuated holding device. The steel saw blade is affixed in position over the working table, it is moved freely to allow for cutting along any line. The motor is hung in a yoke and pulled along a beam by a chain-drive hand-operated crank. (See page 252.)

There are special finishing operations which are intended to suit given materials or a type of work. For example, a dull appearance which typifies the surface of an extruded rod of cellulose nitrate may usually be eliminated by dipping in a solvent such as butyl acetate, leaving the articles clear and smooth on the surface. Press polishing of thermoplastic sheets is well known and widely practiced in the art. In this operation dull sheets, slightly distorted from seasoning, are pressed between two highly polished steel platen, which are capable of developing the desired degree of luster. Rods and tubes may be handled on centerless grinders, followed by a buffing without mounting the rods on centers.

While finishing operations constitute only an auxiliary portion of the complete schedule of preparing plastic pieces, they will contribute excessively to overhead expenses if they are not planned properly, and consequently lower the profits. While they are usually a small fraction of the total cost of the article, in most examples, there are instances in which the finishing operation is as high as 20 percent of the total cost. In jobs of this nature, only those molders with adequate facilities for finishing can hope to offer a bid for the job. In reducing the number of rejects for surface imperfections and in augmenting the desirable qualities of the plastics, finishing operations and equipment are an essential phase of any plastics program.

SUMMARY OF FINISHING OPERATIONS

How Piece Was Produced	Nature of Surface Defect Requiring Finish	Method of Finishing
Molding-compression	Dull surface and flash lines	Tumbling or buffing. Rough finishing for heavy flash and polish
Molding-injection	Sprue entrance to mold	Rough finishing as by filing
Machined (cast phenolics, acrylic resins, cellulose derivatives)	Removal of tool marks	Rough finishing followed by polishing, either by tumbling or buffing
Cast articles (phenolics)	Removal of flash, and develop luster	Sanding belt for heavy flash, polish by tumbling or buffing
Formed or drawn thermoplastic sheets	Slicing knife marks, surface defects from mold	Rough finishing by ashing on wheel, polish on buffing wheel

11



12



11—R. D. Wood Co. 8-opening steam platen press for polishing plastic sheets. The polishing time cycle is governed by the class of material. 12—The Hammond rotary automatic polishing machine will finish small parts of many contours practically automatically

MOLDING *For All Industries*



Sterling injection molded plastics are of higher quality and are produced with greater economy.

BECAUSE we carry your idea from designing through model making; mold making; to the actual molding.

Finishing costs are greatly reduced through efficient mold design and excellent workmanship on molds. We make all our own molds.

Our modern equipment includes three-dimensional engraving and duplicating machines. Also hydraulic hobbing and die-sinking.

STERLING PLASTICS CO.

6 GARDEN ST. NEWARK, N. J.

Applied decoration

PLASTICS are becoming as versatile as the decorations applied and imparted to them—and these decorations are many, indeed. Embossed and intaglio letters and designs on a finished article achieved by means of raised or depressed areas in the steel mold are by no means outmoded, but the various processes and methods of applied decoration developed during recent years are supplementing, and in many cases, supplanting this early technique. New machines and dies, special inks and foils, plating, engraving, printing and stamping processes are all making rapid and important advances.

No one can say that one method of decoration excels another. Each is designed to meet certain requirements set up by individual conditions surrounding the parts being turned out. The point is that almost any decorative effect desired can be successfully applied.

Printing

Printing is extensively used for product identification on molded containers and displays. This type of decoration is also used on fountain pens, radio dials, instrument panels, slide rules and advertising novelties.

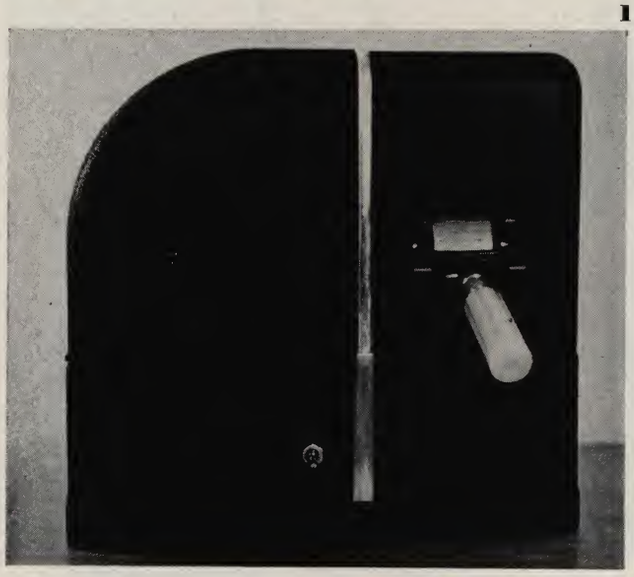
Special inks which adhere to the non-porous surface of plastic materials have been improved so that better permanence is obtained. Special machines have been designed to imprint non-absorbent surfaces by using inexpensive, long-life rubber plates and quick-setting, air-drying chemical compounds prepared especially for this work. A wide variety of time-tested colors is available and the imprinted objects are ready for packing in two or three minutes after the imprint is made. They can be dried on a conveyor belt while being transported from the marker to the shipping department. Round or flat surfaces may be printed with the rubber plates which work equally well on plastics, metal or glass.

Another development in the trademarking field, a machine designed to put two color imprints in one operation on almost any object or surface regardless of size or shape, opens new fields for economical, attractive decorations and trademarks, it is claimed. Colors and designs can be changed in two or three minutes. Correct registration of color and proper location of imprints can be accurately controlled. Special mounted rubber printing plates and marking compounds are employed. The work is accomplished through the use of a hand-operated synthetic rubber roll in conjunction with motor-driven reservoirs and rubber plate holding arrangements so constructed as to provide accurate registration of the two color work. Compact and lightweight, the machine can be moved from place to place as needed.

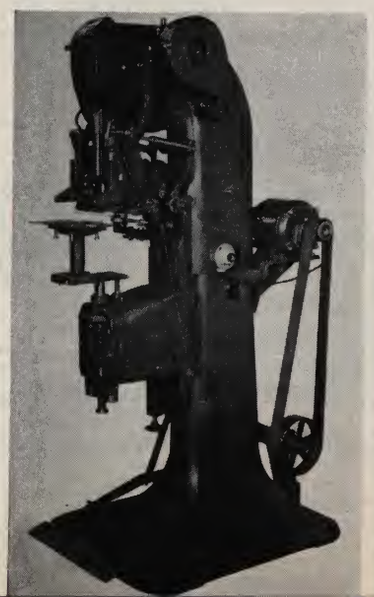
Another process prints embossed lettering and designs on any type of finished plastic product. The printing can be accomplished on flat, spherical, convex, concave, tapered or irregular surfaces with good adherence and with a glossy surface in harmony with the molded part. Any color or shade can be obtained.

By still another method it is possible to print four colors in one operation. Halftones and line cuts may be

1



2



3



1—Two-color trademarking is made easy with the Markem machine which imprints both colors in one operation on almost any surface regardless of size or shape. 2—Designed for large scale high speed production, Markem's Husky Embosser simultaneously indents and colors. 3—Bench-type Kingsley gold stamping press for rapidly imprinting trademarks and other insignia with precise, clear detail



"Transfer" molded gunstock made out of a phenolic impact material and illustrating the exceptional coring possible by this method of molding.

"TRANSFER" molding (injection molding of thermosetting materials) continued to prove its worth during 1940. "Transfer" molding assures maximum dimensional accuracy, uniform cure regardless of cross-section, unlimited coring, and a longer mold life. Parts having fragile inserts, long flow in molds, or intricate shapes are best made by this method. High impact materials, such as canvas filled compounds are most easily handled this way, and with a minimum of finishing cost.

"Transfer" molding is a patented process which was developed and perfected by our organization. Among those licensed to use this process are:

The Boonton Molding Co.
Diemolding Corp.
General Electric Co.
International Resistance Co.
Kurz-Kasch, Inc.
McDonald Manufacturing Co.
Mack Molding Co.
The Thomas Mason Co., Inc.
Northern Industrial Chemical Co.
Norton Laboratories, Inc.
The Waterbury Button Co.
Watertown Manufacturing Co.
Western Electric Co.

We have complete facilities for compression and injection molding. With over forty-eight years of experience in plastics we are equipped to handle your most difficult problems.

SHAW
1892

SHAW INSULATOR COMPANY

CHICAGO • IRVINGTON, NEW JERSEY • NEW YORK

reproduced accurately. Plastic parts are fed into a hopper from which they travel automatically through the printing and drying operations to come out ready for service in a few minutes. The drying heat is so controlled that no shrinkage or distortion results. Thermosetting materials only are printed in this manner.

Thermoplastics are by no means neglected and equally effective methods of printing their softer surfaces are available. Pens, pencils, pocket knives, containers and other products may be printed successfully in all-over designs regardless of shape. Pens and pencils with tapered ends may be printed with no overlap of pattern and no visible joining line.

Such printing is usually done in the printing plant rather than in the molder's shop but printing equipment is available to the molder or manufacturer who wishes to print his own product. Either hand-operated units for simple production jobs or automatic equipment designed for elaborate production schedules, where large quantities are handled, may be obtained.

An idea that promises rapid acceptance in the field of transparent containers is based upon the recent discovery of an ink that permits printing by photo offset on transparent sheets. The finest halftones may be reproduced in this way and may be turned out in speedy production to satisfy almost any demand.

Stamping

Roll leaf stamping is standard practice for branding plastic products with trade names, graduated scales, directions for use and decorative designs. Metal foil and pigmented tape in a wide range of colors is provided for molders and manufacturers to do their own stamping but there are service companies where the work may be done outside the molder's shop if desired.

Heat and pressure are required to force the metallic or pigmented leaf into the plastic surface and it becomes so fused into the material that it cannot be scratched nor rubbed off. The process finds wide application in the packaging field as well as in display.

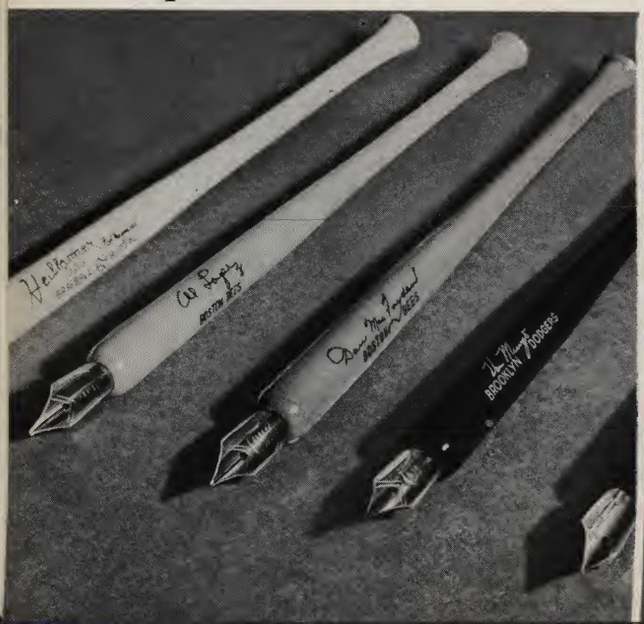
Many types of machines are available for the process of roll leaf stamping. They operate by hand, by foot or by power and may be manually or automatically controlled according to production demands. Roll leaf, composed of either metallic or pigmented colors mounted on paper to provide a means of carrying continuous color through the machine, is placed on a bar in front of the head of the press. The leaf is threaded into a roll feed which carries it beneath the metal stamping die. As each impression is completed, the roll feed pulls new leaf under the die for the next impression.

The equipment required for roll leaf marking consists of a roll leaf stamping press, a steel or brass die or type, and a roll of hot stamping foil. The plastic article to be stamped is placed under the head of the press equipped with the heated die with a roll of leaf passing across its face. With each press operation, the die is forced into the surface of the plastic, transferring the color from the leaf in the same operation. The stamped article is then removed or ejected automatically from the press. There is no drying time required so that it can be packed or used immediately in other operations. This process eliminates entirely the operation of molding in the design or lettering, filling with the color, and wiping off the surplus enamel. Depending on the article to be stamped, its size, shape, as well as the material itself, from 30 to 100 impressions per min. can be obtained on a stamping press.

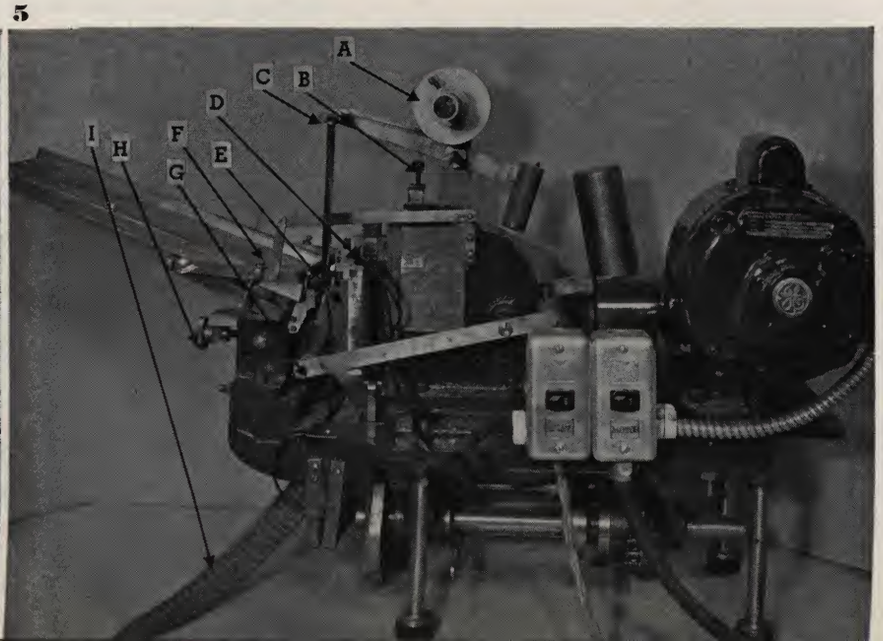
The leaf cost varies from thirty to forty square inches per one cent. The principal cost is the stamping press which can be depreciated over a long period. Most presses are designed for stamping flat surfaces, but there is also available a rotary type press for stamping curved and cylindrical surfaces.

4—Miniature baseball bat novelty pens are imprinted with famous players names in the high speed rotary hot stamping press (5) made by Peerless Roll Leaf Co. From a hopper they are fed automatically into position facing a heated flat brass die over which a web of roll leaf travels. A—roll leaf holder; B—roll leaf adjusting screw; C—roll leaf breaker bar; D—automatic heat control; E—chase; F—stack feed; G—tension bar; H—pressure adjusting screw; I—leaf showing impressions

4



5



PACKAGING
an important market
for PLASTICS

Packagers are using more and more plastics—offering plastics molders and fabricators an important market for their products.

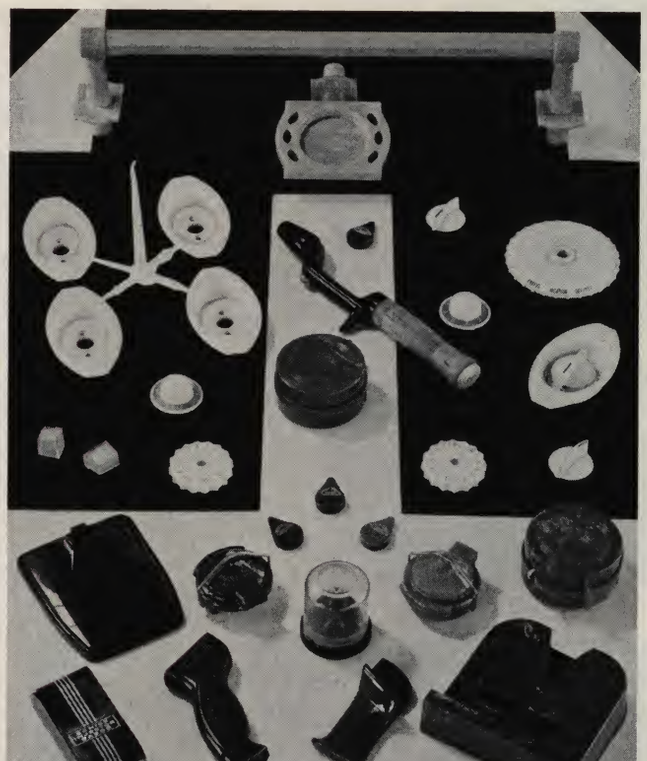
Packagers use plastics to build sales. And, in view of the present uncertain international situation, the future may demand an even greater use of plastics in packaging to replace essential materials unavailable through bockade or legislation.

Get to know this market—its problems and possibilities—through the magazine which covers it completely from every angle. MODERN PACKAGING is the magazine many leading molders read to know what packagers are doing, what they need, what they may do. And, they use it as their medium to advertise to the packagers of America. Packaging is a market of billions of dollars annually. And MODERN PACKAGING does a complete job of both reporting and reaching the packaging field.

Subscriptions:
United States $5.00 one year, $8.00 two years.
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Space Rates on Request

MODERN PACKAGING
122 E. 42nd Street **New York City**



Accomplishments Like These

HAVE DOUBLED THE SIZE OF OUR PLANT

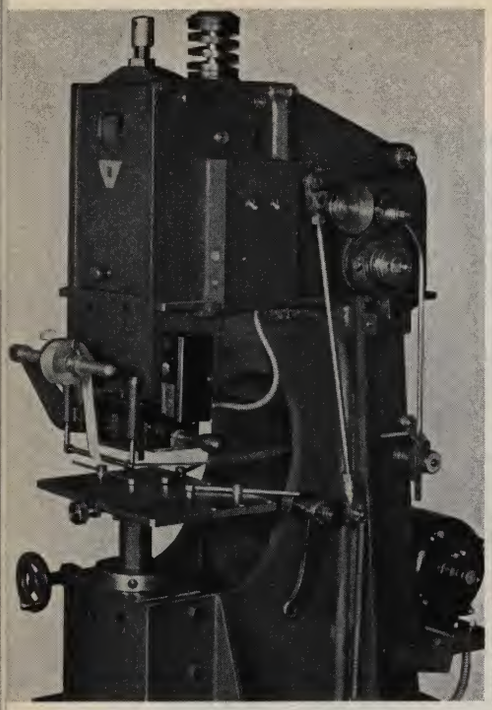
Columbus Plastic Products, Inc., starts the year with a greatly enlarged plant. Equipment for more diversified jobs has been added. A business expands ONLY when the demand for their service increases. Those are facts to consider when buying plastic molding.

We can efficiently and economically handle injection molding of cellulose acetates, polystyrene, butyrate and other thermo-plastic materials.

Just send us specifications. Our experienced product designing and engineering department will be glad to study your problem and submit recommendations.

INQUIRIES ANSWERED PROMPTLY

COLUMBUS PLASTIC PRODUCTS, INC.
519 DUBLIN AVE. COLUMBUS, OHIO



6



7



8

6—Electrically operated hot stamping machine for gold or pigmented leaf by Griffin, Campbell, Hayes, Walsh, Inc., has a "compensating device" to allow for variations. 7—Powerful foot-propelled imprinting machine produced by Ackerman-Gould Corp. is adjustable. Entire head of the press can be raised or lowered 4 in. 8—Collection of vari-shaped articles ornamented in color by Plastiglas Printing Co. Contour places no limitation on decorative applicability

Presses are equipped with mechanical handling and compensating devices which take care of any nonuniformity in thickness and shape of the pieces being stamped. Stamping presses have been highly developed for rapid production of special applications, often in conjunction with drilling and other finishing operations which complete and stamp the part without any manual attention being required.

One company specializing in this field has designed a high-speed rotary hot stamping press claimed to stamp hundreds of round-surfaced articles an hour using flat brass dies which can be readily changed. The machine (shown on page 258) was designed specifically to decorate miniature baseball bat pens and pencils. The items to be stamped are placed in a hopper from which they are fed automatically into position facing a heated flat brass die over which a web of roll leaf travels. With each press operation, the article is rolled across the face of the die, and the design is engraved into the surface of the plastic material, the color being transferred at the same time. The roll leaf feeds automatically the exact amount required for each impression, which can be adjusted to suit different depths of stamping dies.

One firm has developed for its stamping machine a special process of photo-engraving directly on brass hot-stamping dies at a considerable saving over the cost of hand engraving.

A new, complete, electrically operated hot stamping unit has been designed by a leading manufacturer especially for stamping gold or pigmented leaf on molded plastics. A unique feature is a *compensating device* that is reported to allow for variations naturally present in the great variety of plastics. There is also an *impression control* that provides for varying thicknesses in different types of work and for the time of dwell at the bottom of the stroke.

With the perfection of the process and the availability of white and other pigmented colors, roll leaf stamping has displaced much wiping in by hand which used to be done to obtain contrasting letters and numerals.

Engraving

Engraving may be done by hand or by portable engraving machines. These machines use no heat. Instead, a small rotary tool guided by hand cuts lettering or designs into the plastic part. Although guided by hand, it operates on the pantograph principle whereby the operator traces the outline of larger letters while the tool cuts them into the plastic in reduced size. Small lightweight portable machines designed to reproduce letters, designs, emblems and signatures on small plastic items, particularly at point-of-sale, are gaining favor.

A bench-type pantographic machine for general industrial engraving work on all materials has separate heads that are quickly interchangeable. On engraving work, the depth of cut is controlled, independent of the depth of master characters, by a micrometer adjustment mechanism on the engraving head. Smooth lines can be cut on flat or round surfaces fairly rapidly and no special skill is required for operation. Either raised or sunken engraving can be produced. For engraving on uneven surfaces, or slightly concave or convex surfaces, or on objects varying in thickness, an automatic depth-of-cut is furnished.

Decalcomanias

As old as the hills, this method of decoration is just being introduced successfully for the decoration of plastic surfaces. The delay was occasioned because the usual adhesives that hold decalcomanias in place were ineffective on plastics. They wouldn't stick. Special



A Smart Piece of Reminder Advertising Moulded by K & J for Alfred Robbins Organization

Mark this down on *Your* Calendar

"Get in touch with K & J".....

We'd like to demonstrate our versatility in moulding plastics—whether it be a gadget or an intricate piece that must meet precision limits. We'd like to show you exactly how our "straight-line" production works to your economical advantage. Here's the set-up we offer:

- **Designing and Engineering Staffs,** thoroughly familiar with materials and applications, incorporating modern design in practical moldings that fit their job perfectly.
- **Mould Making Shop,** equipped for speedy and economical production and using the finest quality mould steel to assure uniformity, whether your order be for two or two million.
- **Moulding Department,** fully equipped with modern presses for moulding of phenolic, urea, thermoplastic compounds and Thiokol.

Kuhn & Jacob
MOULDING and TOOL CO.

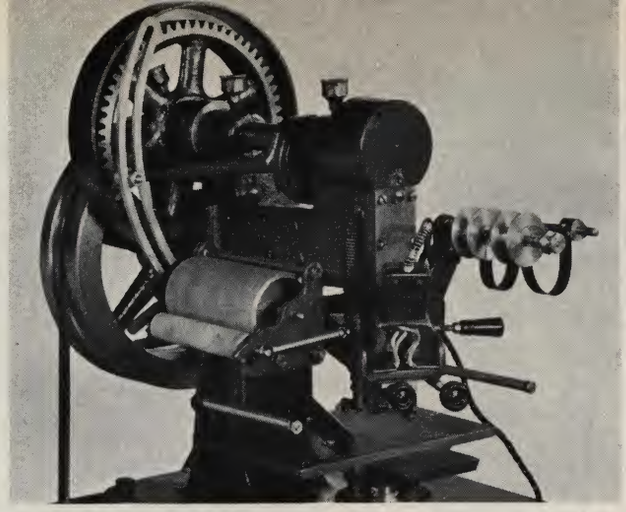
1203 Southard St., Trenton, N. J.
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IN PLASTIC MOLDING—AS IN EVERY OTHER FIELD

QUALITY HAS NO SUBSTITUTE

We are producers of precision moldings for industry. We do compression and injection molding of all plastic materials, both thermo-setting and thermoplastic. Consult us for a satisfactory solution of your molding problem.

PEERLESS MOLDED PLASTICS, INC.
TOLEDO, OHIO







9—Sturdy motorized stamping machine for plastics made by Simplex Gold Stamping Press Co., Inc. 10—Three-dimensional pantograph engraving and electric etching machine by H. P. Preis may be supplied with various master copy type foils. 11—Automobile name and decorative parts of injection molded cellulosic materials, inlaid with metal by the Chilton Process, by Plastic Inlays, Inc., achieves striking results

solutions, in which the plastic surface is first treated, now provide a satisfactory adhesion and some unusual effects are obtained. Decalcomania decoration on plastic surfaces in the package and novelty field are practical applications of this easily applied ornamentation.

Metal inlays

There is an increasing tendency to combine plastics with metal, both for structural and decorative reasons.

9 The contrasting gleam of metal against the lustrous surface of plastics enhances the appearance of both materials. Interesting patterns of light are picked up and reflected by bits of metal embedded in the more somber plastic background.

There are any number of places where metal inlays are practical and attractive. You will find them in your 1941 automobiles, in radio knobs and grilles, in fountain pens, in plastic displays, cosmetic containers, handles on commonplace household equipment, and in advertising and directional signs.

10 There is no limit to the design possibilities of decorating with metal because any pattern or design that can be cut from thin stock can be inlaid in plastics by one method or another.

Inlays may be molded into plastic pieces or put in after the piece is molded. The latter method has seemingly proved more popular. One company has perfected automatic machinery to handle metal inlays with such facility and speed that quantity production is now available without limit. These inlays are forced into plastic surfaces cold, yet they are so shaped that they become anchored permanently.

Other inserts and trade name plates may be attached to the plastic surface as the final finishing operation and patented drive screws or speed nuts are used to hold them securely in place.

11

Metal plating

Although plastic materials do not conduct electricity, they can now be plated by a simple and highly efficient process. A firmly adherent and highly conductive bond coat is formed on the surface of the plastic and the metal is electroplated thereon. This bond coat may be applied to the entire surface or any desired portion. Due to the permanent adhesion between the metal and the plastic an extremely thin deposit of metal is sufficient to withstand buffing, shock, wear and variations of temperature.

In designing fixtures of all kinds the trend is definitely toward bright chromium and rich gold finishes. Complicated shapes which could not be economically made of metal, can be molded of plastic and plated to obtain the desired effect. By plating the metal on specified regions of the plastic material attractive designs and contrasts can be obtained between the pleasing plastic colors and the bright metal finishes. This method is being used extensively in plating novelties, dress ornaments, bottle caps, knife handles, and among the most recent applications are found control knobs, electrical and radio parts, rollers, cams, gears and industrial parts.

In general it is found that complicated small knobs, push buttons and other parts can be molded of plastic for a fraction of the cost of making the same part in metal. This is especially true of heavy die castings and screw machine parts. Of course, where plating is contemplated, inexpensive plastic materials can be utilized. As a result, the total cost of a chromium plated plastic part is less than what a similar unit would cost if made of metal and chromium plated. This plated plastic

It Might Have Been You . . .



These products, Award Winners in the 1940 Modern Plastics Competition, illustrate the creative abilities, engineering design and quality workmanship which are at your service for your own product improvement.



Yes... it might have been you who enjoyed the honor of a Modern Plastics' Award—the symbol of a plastic product ingeniously designed, expertly made.

Of course, we can't guarantee that your product would receive the Judges' nods. But we can and do guarantee that when you entrust us with your job, your product receives the utmost in engineering skill and expert workmanship to make it as outstanding in quality as are those of our products honored in the 1940 Modern Plastics Competition.

So save time and worry. Treat yourself to satisfaction with your next injection molded job. Call on the Elmer E. Mills Corporation. Let our engineers give you the benefit of their knowledge of product design. Enjoy the advantages of our injection molding technique that makes each product of Championship quality. You'll appreciate the difference.

Elmer E. Mills Corporation molds thermoplastic products by the injection process, of the following materials: Tenite . . Lucite . . Lumarith . . Plastacele . . Crystallite . . Vinylite . . Polystyrene . . Styrene and other Thermoplastic Materials.

MILLS PLASTIC PRODUCTS

ELMER E. MILLS CORPORATION

820 WEST VAN BUREN STREET · CHICAGO, ILLINOIS

LEAROK

THE BUFFING COMPOUND WITH NO FREE GREASE

LEAROK—The Clean Compound Without Free Grease for Cutting and Buffing

8 Grades for Cutting
11 Grades for Cut and Buff
7 Grades for Buffing

List of Plastics for which LEAROK has been tested and proved

PHENOL FORMALDEHYDE MOLDING

Bakelite, Catalin, Celeron, Durez, Durite, Heresite, Inclur, Insurok, Uniplast, Makalot, Neillite, Resinox, Textolite

PHENOL FORMALDEHYDE CAST

Bakelite, Catalin, Gemstone, Marblette, Monsanto CP

UREA FORMALDEHYDE MOLDING

Bakelite, Beetle, Plaskon

ACRYLATE & METHACRYLATE

Crystalite, Lucite, Plexiglas

STYRENE

Bakelite, Styron

HARD RUBBER

Ace, Luzerne, Rub-Tex

CASEIN

Ameroid, Gala, Galorn

ETHYLCELLULOSE

Ethocel

CELLULOSE ACETATE

Bakelite, Lumarith, Masuron, Monsanto CA, Tenite, Nixonite, Plastacele

CELLULOSE ACETATE BUTYRATE

Tenite II

CELLULOSE NITRATE (Pyroxylin)

Celluloid, Monsanto CN, Nixonoid, Pyralin, Soy Bean

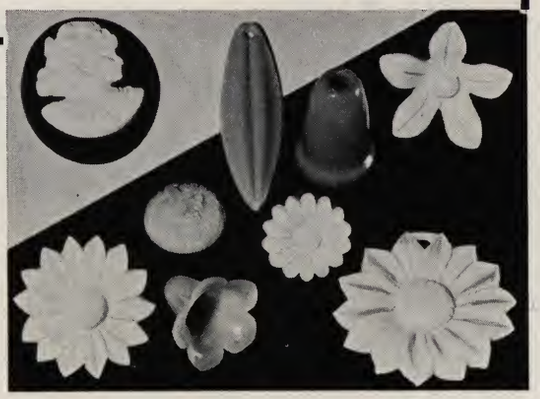
The above information is indicative of the extensive research work we have carried on in the past few years in adapting this widely used compound—LEAROK—to plastics. We suggest that you send us samples of your work with an outline of what you wish to have done. Our technical men will recommend the grade of LEAROK which should reduce your costs of cutting and buffing.

THE LEA MFG. CO.

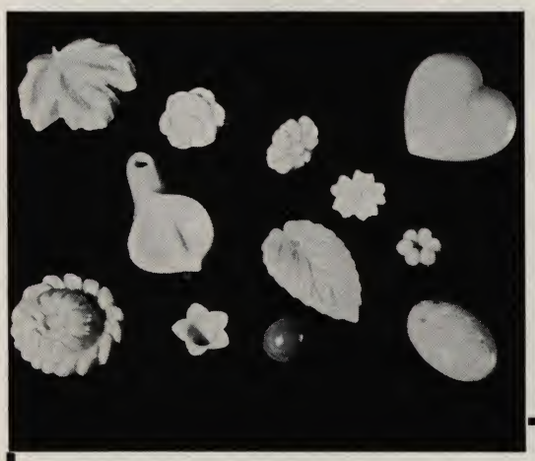
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We have complete facilities for making our own molds by a competent staff of mold makers with twenty years' experience.

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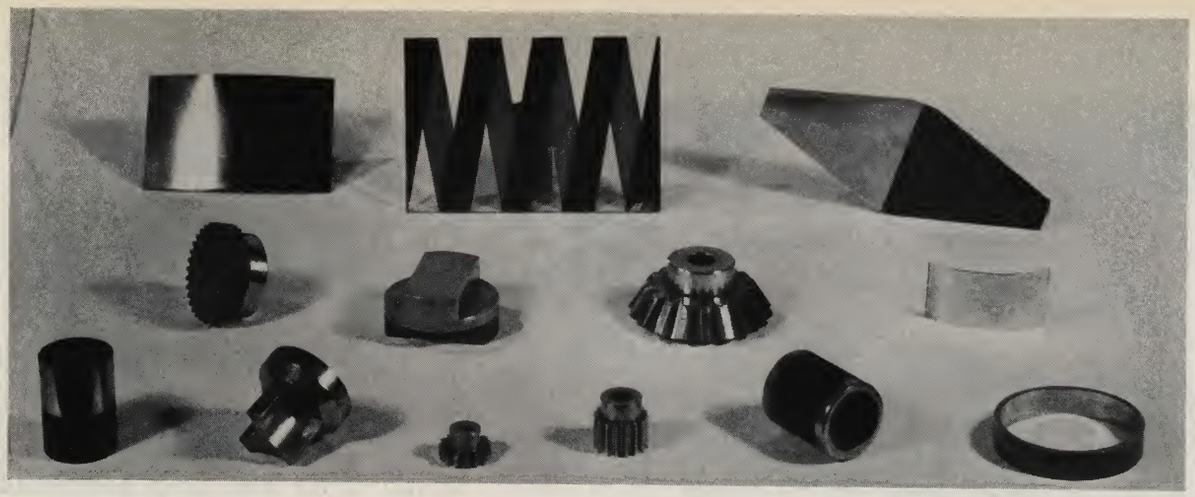
CHROMIUM CORPORATION OF AMERICA

Executive Offices ... 120 Broadway, New York

346 Huntingdon Avenue
Waterbury, Conn.

1760 Lakeview Road
Cleveland, Ohio

4645 West Chicago Avenue
Chicago, Ill.



12—Improved technique in metal plating plastics is shown in these industrial applications prepared by Metaplast Corp. These include thin laminated sections plated to prevent denting or deforming; transparent sheet (top center) with spiral copper band to show electrical possibilities of combining conductor and insulator; laminated gears, tubes and rings plated to resist wear and to provide a condensing surface without affecting their lightweight or quiet operation. Other parts are silver-plated for use with fluids apt to be contaminated by free phenol, and to secure a suitable surface for sterilization and cleaning

weighs much less than its metal equivalent and has a considerably greater resistance to denting, bending and deforming caused by impact and dropping. As a result, thin lightweight plated plastic sections having the appearance of highly polished metal are used without the customary denting which is found when thin metal sections are employed.

By plating certain parts of the surface of a plastic material, electrical units, combining the properties of a conductor and insulator in one integral part, are possible. As the metal and the insulator material are firmly bonded together there is no possibility of the metal loosening up to change the capacity of the unit, and vibration and rattling are completely eliminated. As the surface hardness of plastic materials is not sufficient for many industrial applications it has been found advantageous to deposit hard chromium at the points of wear, thereby increasing the life of the part and in some cases making possible the use of a light-weight plastic where it would otherwise be unsuited. This deposit also resists attack due to oils, moisture and other fluids. This metal deposit also removes any static electricity which might form on the surface of the plastic, which would be objectionable for many reasons, such as collecting dust, electrical interference, etc. Gears, rollers, valve parts, indicators and other parts made of laminated or molded plastic materials are being plated to take advantage of one or more of the above mentioned properties of the metal deposited. Methods and equipment have been devised and perfected for bonding, plating and finishing all types of plastic productions. In all these operations small parts can be tumbled by the thousands. For larger pieces, racking and spraying methods have been designed to reduce handling to a minimum—assuring maximum efficiency in output, materials and labor.

One concern which has worked out this process for plating plastic material maintains a laboratory and pilot plant to help determine in what applications it is advantageous to plate plastics or replace metals with plated plastic materials.

13—Automobile and other manufacturers are finding lacquered transparent plastics add to the general decor of their products. "See-Deep" horn assembly emblems are by Cardinal Corporation

13



Three-dimensional effects

For the decoration of high quality parts a new treatment for lacquering transparent plastics has been introduced. Generally used for the overall coloring of a molded part, it has been found to be of particular value for such articles as horn buttons, nameplates and radio and automotive bezels, and is applicable to most decorative parts where a slight increase in cost over ordinary moldings is warranted by the increased attractiveness.

By a new method it is claimed possible to produce delicate contrasting colors on the rear surface of a transparent molded piece, and to obtain considerable illusion of three-dimensional depth, while still preserving a smooth exterior contour. Effects of this sort can be carried to a point of refinement approaching a jewel-like feeling.

This type of finishing makes possible the brilliance of a great many metallic colors in the overall finish of the piece which cannot be obtained in ordinary plastics. These metallic backgrounds, coupled with the three-dimensional relief, make possible a new interest and texture in plastics. The effects can be subtle or garish as the occasion demands, and are especially useful in relieving the monotony of a solid color in large molded pieces. Especially novel illuminating effects are made possible by this method of finishing clear moldings.

Investigate the NEW

HAWK BRAND POLISHING PLATE

For a Finer, More Perfect Finish on Plastic Sheets



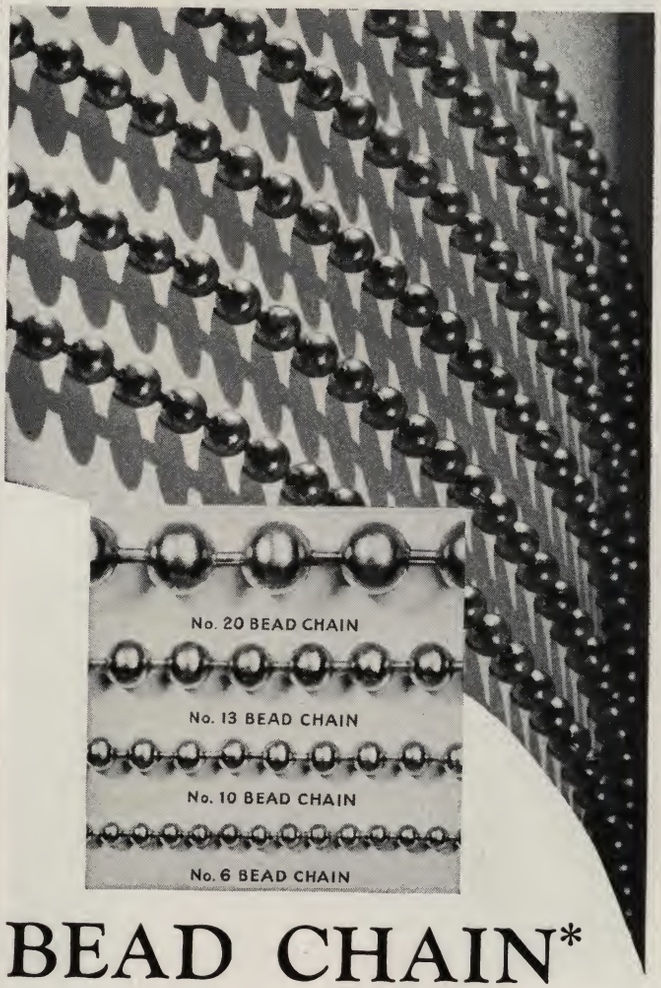
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The swiveled construction of BEAD CHAIN* permits its use in many ingenious ways. It is made in sizes and with couplings to fit the need, and the smooth metal beads have a decorative value that is frequently most desirable. When color is required, BEAD CHAIN* may be had in durable lacquered finishes.

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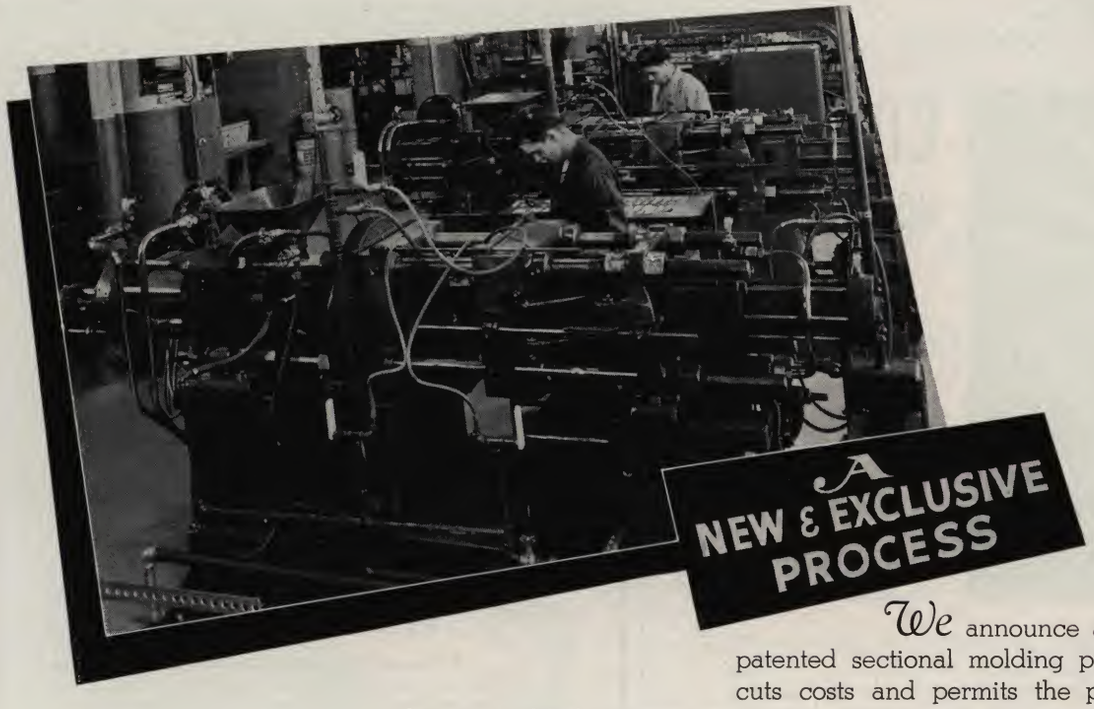
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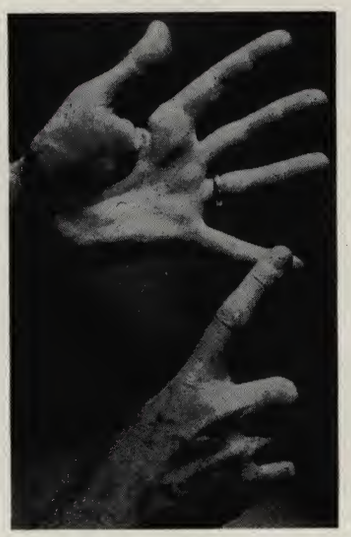
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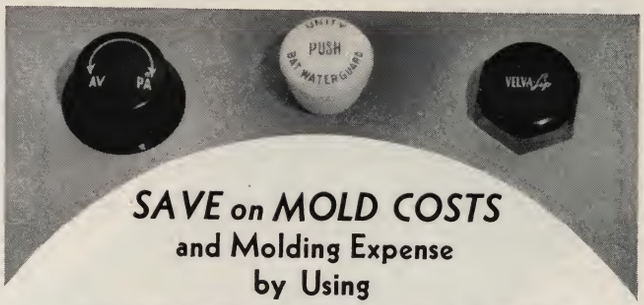
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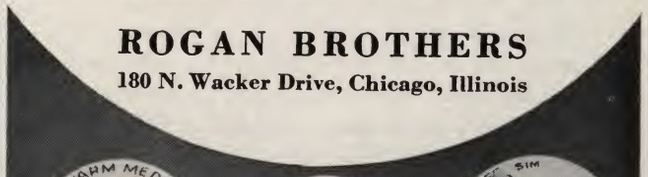
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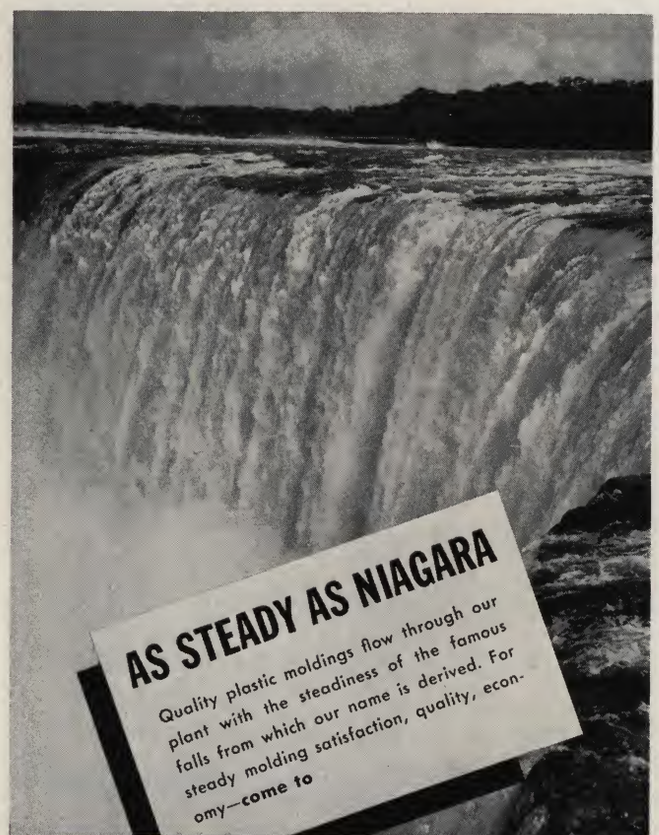
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Our long experience and modern plant will be found useful in creating, molding and assembling.

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815 Main St. . . . . Bradley Beach, N. J.

MACHINERY and EQUIPMENT

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Assembly devices—352

Plant equipment

Molding plant equipment—360

Resin plant equipment—380



Preforming presses

PREFORMING consists simply of compressing molding powder into tablets or *pills* of various size or into shapes which conform more or less to the form of the part to be molded. These preforms are made in automatic presses developed especially for the purpose, may be used immediately or are readily stored for future use, are of predetermined weight and density as well as form, and their use in the production of plastic moldings is highly advantageous in many operations. They serve to speed up molding operations, reduce flash losses and waste material due to overloading and achieve savings in mold cost.

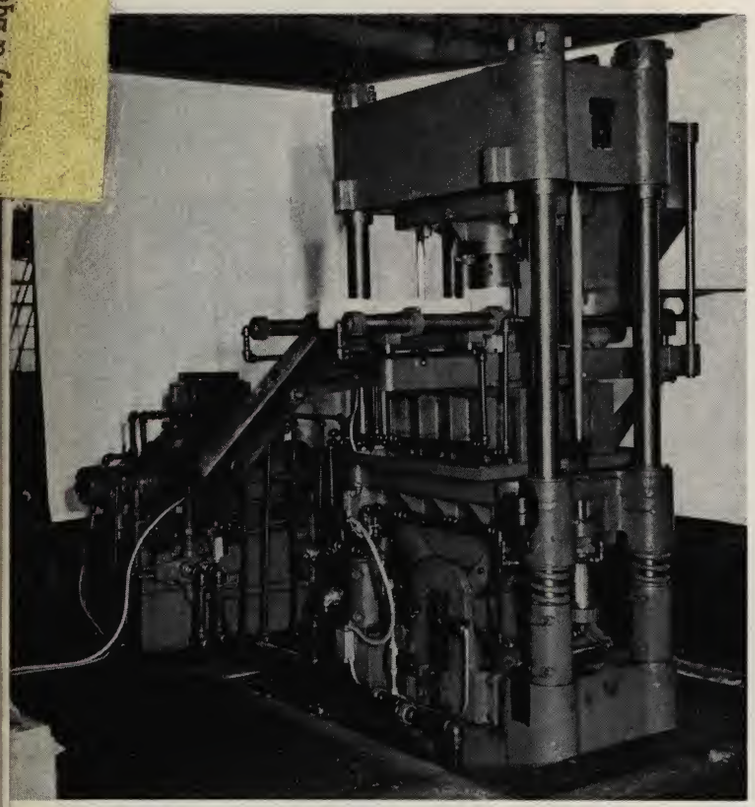
Preforming offers greater advantages, however, in speeding up production of the molding press on many classes of work and in improving the physical properties of the moldings produced, particularly those of intricate shape in which the material is more uniformly distributed when a properly shaped preform is used. Preforms are dense, therefore, the material plasticizes more rapidly than when in loose powder form. Flow is quicker. Cure is faster. The press is capable of a greater number of heats per hour. And frequently a mold with a lesser number of cavities will produce moldings in the required volume . . . which, of course, reduces initial mold cost.

Another reason why greater output per press is possible when preforms are used is because the mold requires less depth, the powder already having been reduced to about half its original bulk, therefore there is less movement of the ram in opening and closing. Preforms are cleaner and much more convenient to handle and load into the molding press than loose powder in the conventional loading board. Some material wastage is thus prevented at the loading point.

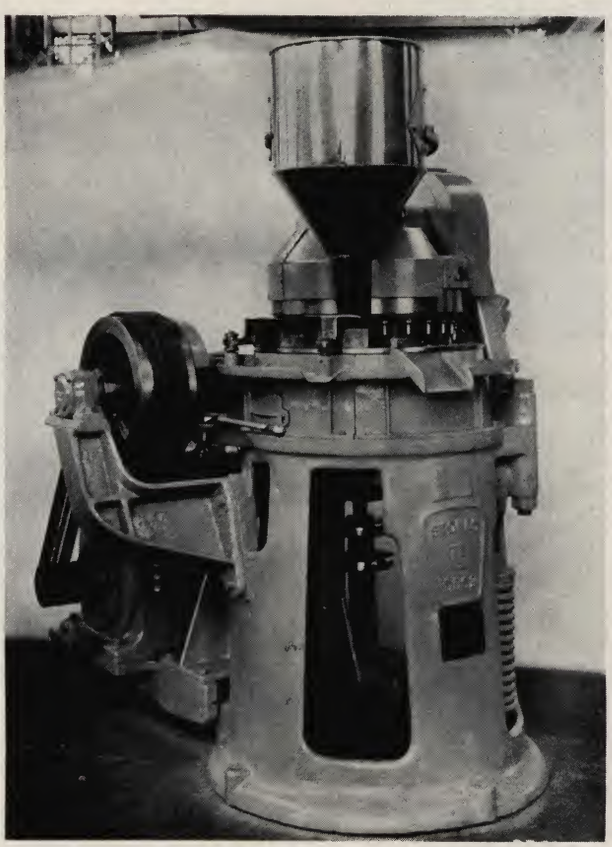
The trend toward larger preforms is a natural result of the increasing demand for larger moldings. Heavy duty, toggle operated presses now on the market are making preforms up to 4 in. diameter and 2 in. thick under pressures up to 80 tons per square inch. Another

(*Please turn to page 295*)

1



2



1—F. J. Stokes Machine Co. makes this 300-ton toggle type preforming press arranged for completely automatic operation. A readily adjustable dwell period reduces to a minimum air trapping of the preforms. Adaptable for single or multiple cavity dies with or without cores. Operating speed, 8 strokes per minute and maximum depth of fill, 8 inches 2—Each minute, 350 preforms can be turned out by this Stokes rotary preforming press. Keeping the hopper filled and removing drums into which preforms fall is the only attention it requires in operation

Speed Nuts



The symbol of speed and savings on the assembly lines of leading products everywhere ★ ★

Patented Development of

TINNERMAN PRODUCTS, INC. ★ CLEVELAND, OHIO, U. S. A.

IN CANADA: Wallace Barnes Co., Ltd., Hamilton, Ontario • IN ENGLAND: Simmonds Aerocessories, Ltd., London • IN FRANCE: Aerocessoires Simmonds, S. A., Paris

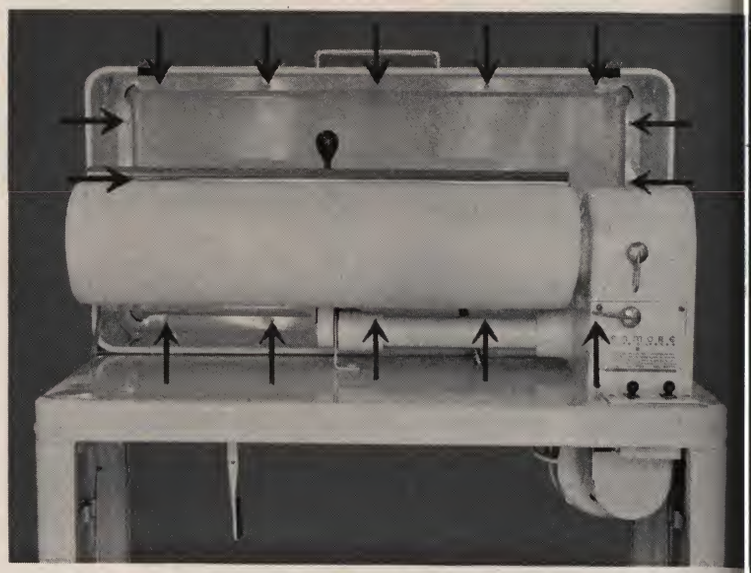
Speed Nuts

TO REPLACE THREADED NUTS AND LOCK WASHERS

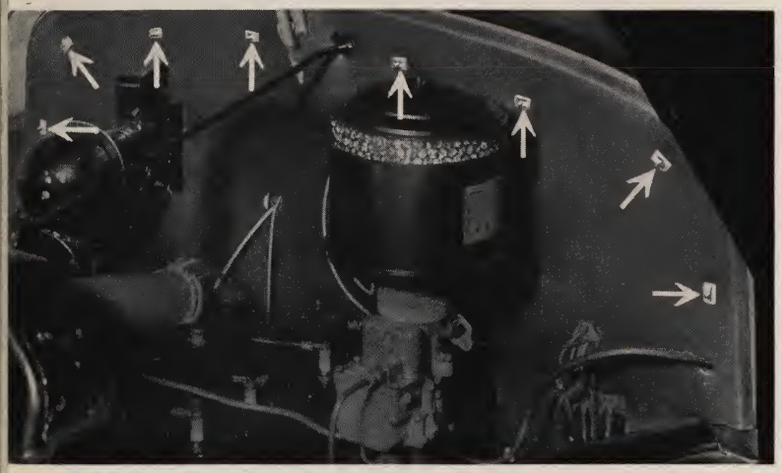




Illustration shows typical warm air furnace construction on which SPEED NUTS are used throughout the entire assembly. Threaded nuts and lock washers are replaced at a saving of at least 50% on handling time alone. SPEED NUTS provide double-locking spring tension that absorbs stress and strain caused by expansion and contraction and eliminate loosening from vibration.



SPEED NUTS are used in the assembly of the electric ironer cabinet top in the positions shown. They cut assembly time, for with SPEED NUTS you don't have to "find the thread". The assembly operator ZIPS the SPEED NUT over the threads of the bolt and completes tightening with a turn or two of a hand or power screwdriver.

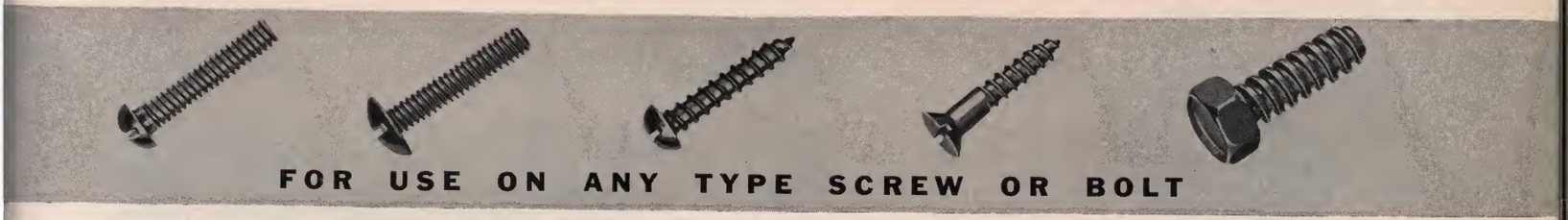


In the illustration above, SPEED NUTS are used to fasten the insulation to the automobile engine dash. By providing a wide bearing surface, they eliminate spanner washers and prevent tearing of the insulating material.



In the manufacture of space heaters, SPEED NUTS are used generally throughout the assembly. They have overcome one of the greatest problems of the appliance manufacturer — the delivery of the product to the ultimate consumer in first-class condition. Transportation vibration will not loosen SPEED NUT assemblies, all parts are retained in fixed position.

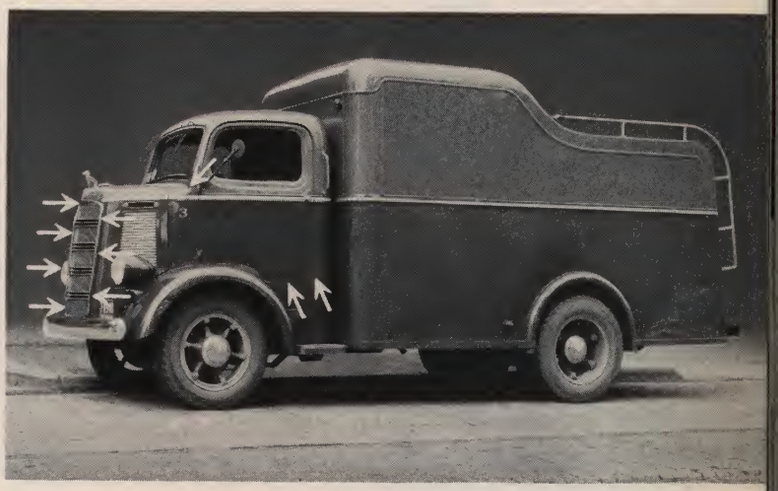
PROVIDE DOUBLE LOCKING SPRING TENSION ASSEMBLY



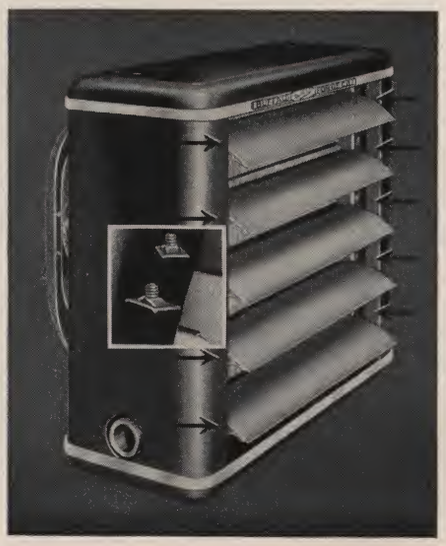
FOR USE ON ANY TYPE SCREW OR BOLT



In the construction of porcelain enameled cooking ranges or similar products, SPEED NUTS are indispensable; they provide a positive fastening yet are sufficiently resilient to prevent straining the porcelain beyond its elastic limit. As the range is heated, it expands but the SPEED NUTS allow the panels to "float" independently of each other, preventing chipping or cracking.



The arrows point to a few of the many SPEED NUT applications that defeat the vibration of trucks; fastening floor boards to main body, rear fender to wheel house panel, glove box to instrument panel, front fender braces to fender, dash and body insulation, and holding radiator core to supporting frame.



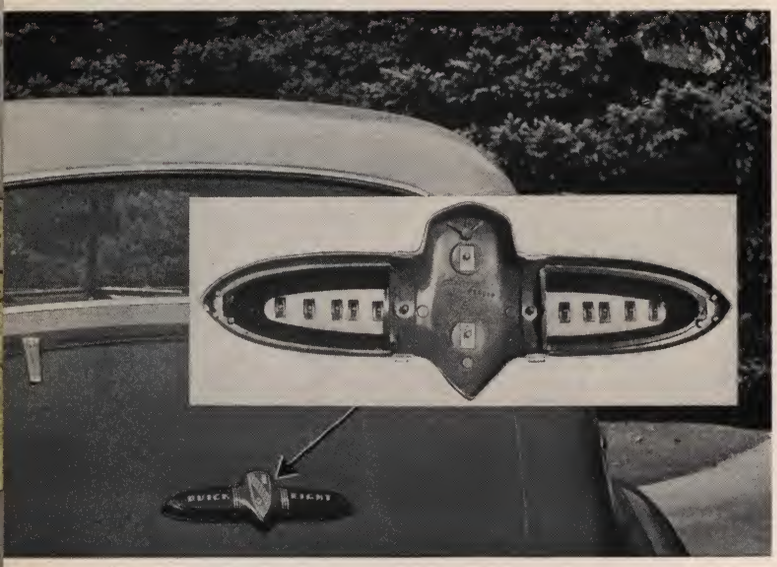
SPEED NUTS are ideally suited for fan louvre assembly; they also provide frictional spring tension to adjust louvres to any desired position. Here, SPEED NUTS replace coil springs, washers, cotter pins and eliminate machining operations.



In aircraft construction, SPEED NUTS are used in the assembly of engine cowlings, name plates, instrument clusters, exhaust fairings, wheel pants, seats, spinners, etc. Vitally important is the lighter weight of the SPEED NUT and its double-locking vibration-proof spring tension grip. Double-locking because it gives a radial biting grip into the root of the bolt thread and locks the assembled parts under live spring pressure.

Speed Nuts

TO LOCK UNTHREADED STUDS

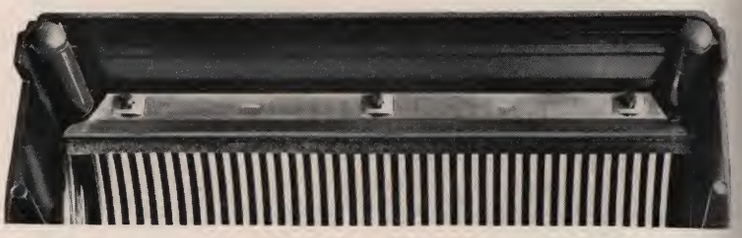


The ten die-cast letters, the two trim strips, and the medallion are held by merely zipping the SPEED NUTS over integral unthreaded studs. The biting grip of the SPEED NUT prongs prevent any possibility of loosening. The SPEED NUT System effects great savings by eliminating costly threaded inserts, drilling, tapping—and by fastening many parts at one time.



Here is an example of how one SPEED NUT often replaces many parts. In the Automatic Radio Selector Bracket illustrated, one SPEED NUT replaced a coil spring, washer, cotter pin and drilled hole. It provides a firm grip with just the right slidable spring tension.



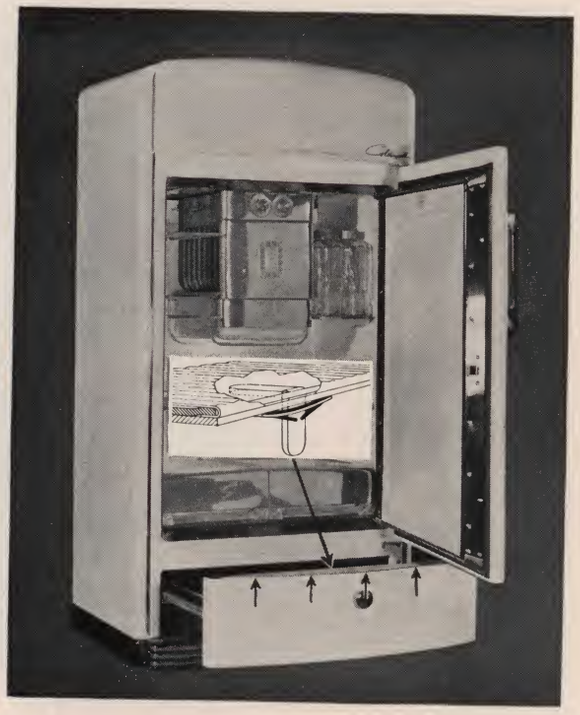


6 "push-on" type SPEED NUTS are used to assemble the plastic record holder illustrated. It is moulded in one factory and shipped bottom up in individual containers to another plant for assembly. Upon arrival, assemblers open cartons, position the two record supports, then press SPEED NUTS over the six integral studs of the record holder to complete the assembly without removing product from carton.

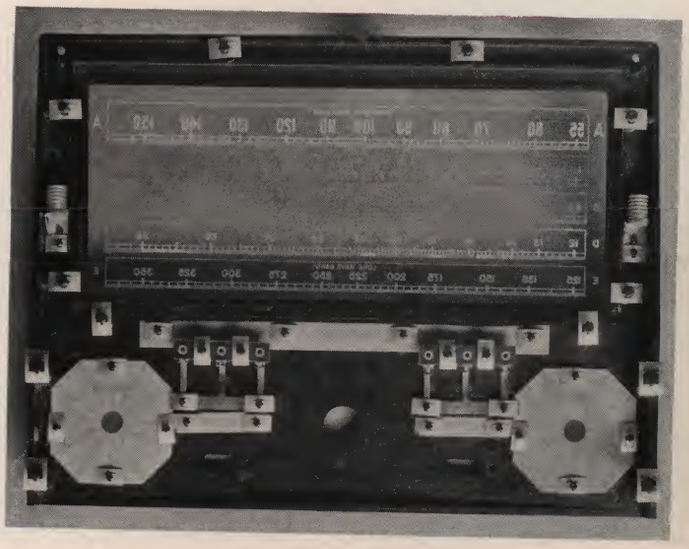


The die-cast oven grille on the electric range has integral "D"-shaped studs over which SPEED NUTS are pressed to assemble grille to panel. Often "D"-shaped studs are used for removable assemblies because a 90° turn of the SPEED NUT quickly releases it. Sides are turned up for use of wrench for removing. Arrows also indicate where push-on type SPEED NUTS are used on plastic and die-cast escutcheons and name plates.

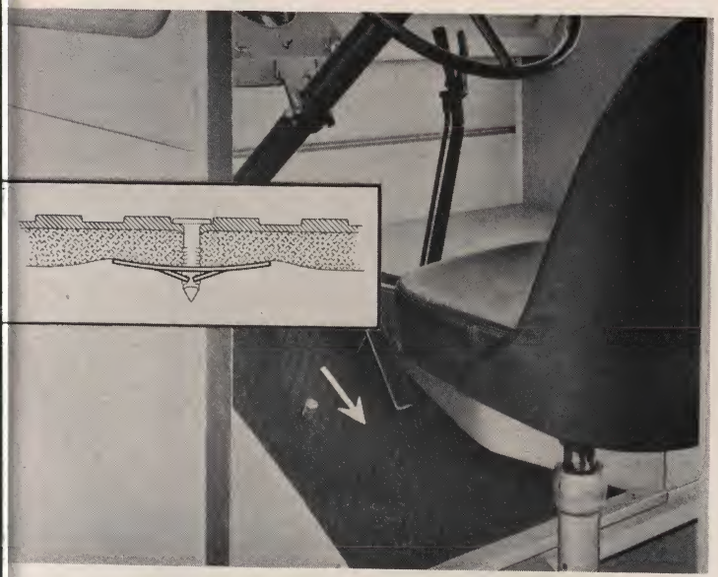
ELIMINATE INSERTS IN PLASTICS AND MACHINING OF DIE CASTINGS



This refrigerator has a stainless metal trim over the top edge of the door and storage drawer. Tabs are sheared and formed from the under part of the trim itself. This illustrates the versatility of SPEED NUTS which can be used over irregular shaped tabs as well as rivets, nails, wire and integrally formed studs.



This unique radio dial panel assembly shows the widespread use of SPEED NUTS in assembling moulded plastic parts. By fastening to integrally moulded studs, SPEED NUTS eliminate threaded inserts, reduce mould costs, simplify the process and greatly reduce assembly time. SPEED NUTS can be used on studs of either thermo-setting or thermo-plastic material.



In this cab-over-engine truck, SPEED NUTS have a unique application in fastening insulation to under-side of floor board. Being 1¼" square, they eliminate large washers or retaining strips and hold the soft insulation without sagging. No. 11 gauge nails are used by merely pushing them thru the insulation into the SPEED NUTS.

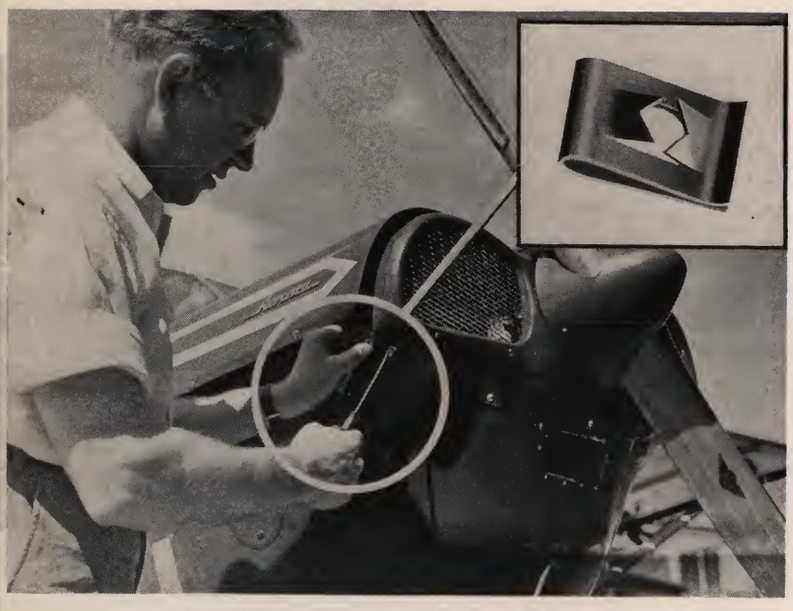


SPEED NUTS have a universal application in the assembly of name plates and emblems. Whether die-cast, die-cut, plastic or etched, all that the name plates need are integral or sweated studs for SPEED NUT attachment. No threads are required, for SPEED NUTS provide a positive lock to even the smoothest chrome surfaces. Illustrated above are just a few of the hundreds of nationally-known product name plates using the SPEED NUT System of assembly.

Speed Nuts

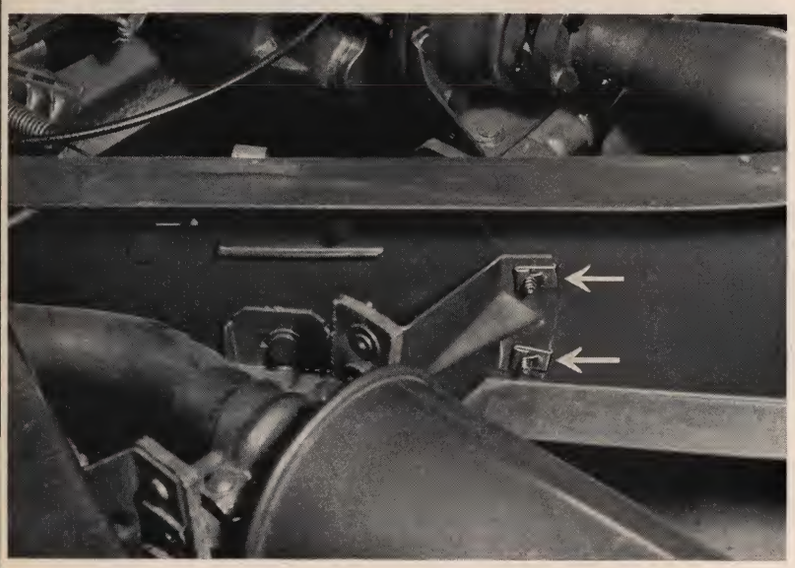
WITH "MECHANICAL HANDS" TO HOLD THEM IN PLACE

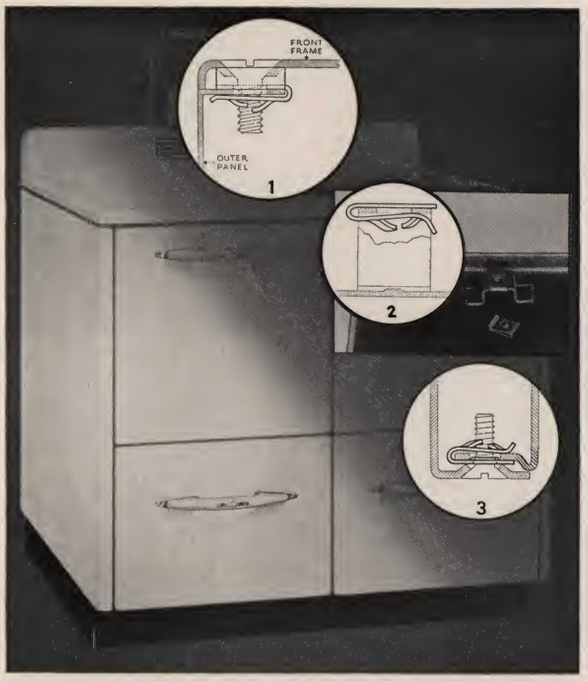




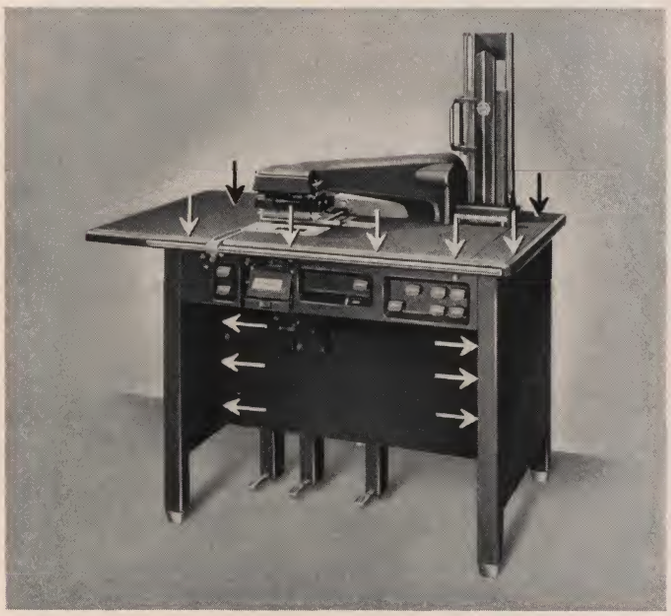
This illustration shows one of the many "U" type SPEED NUT applications. When pushed over the flange and into the holes along edge of cowling, SPEED NUTS stay in bolt receiving position so that the operator needs no access to opposite side and has both hands free for completing assembly. Important to air craft, SPEED NUTS are light in weight and vibration-proof.

The muffler assembly is a typical "U" type SPEED NUT application on automobiles. Being self-retaining and quicker to apply in blind and difficult locations, they are also used on fenders, fender braces, head lamps, muffler supports, tail pipe hangers, radiator shields, and grilles, glove boxes and doors, hood sides, alligator hood hinges, heaters, seats, transmission cover plates, hood top braces, head lamp adjusting screws, etc.





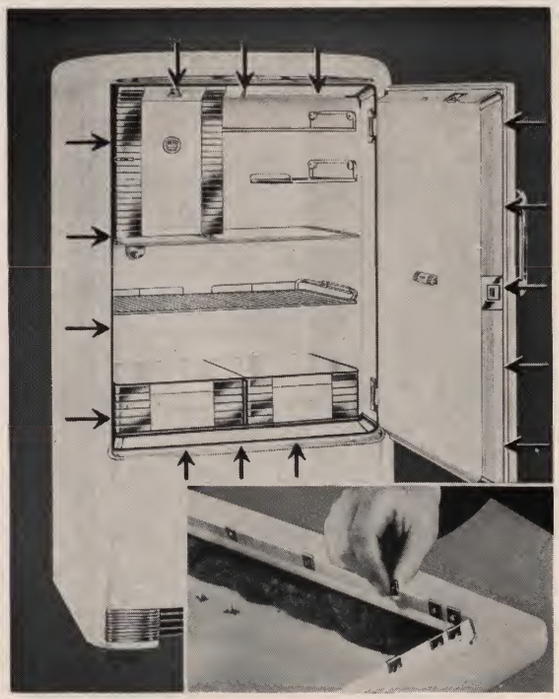
The electric range illustration shows 3 of the many uses of "U" type SPEED NUTS in range assembly. They are used to advantage as illustrated on end panel (1), door (2) and liner (3) assemblies. In all cases, they hold themselves in bolt receiving position and fasten with a resilience that prevents enamel damage.



"U" shaped SPEED NUTS are used throughout the assembly (as arrowed) of business machines because their double-locking feature prevents loosening from vibration, and they reduce assembly costs. This type SPEED NUT eliminates the handling of various assembly parts wherein it was formerly necessary to weld or rivet tapped strips, or pocketed nuts in place.

SNAP INTO HOLES WITHOUT WELDING, RIVETING, OR HANDLING OF PARTS



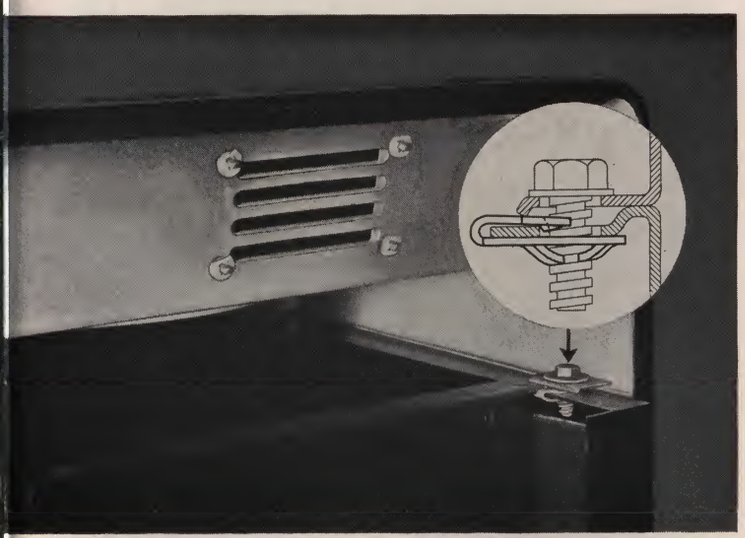


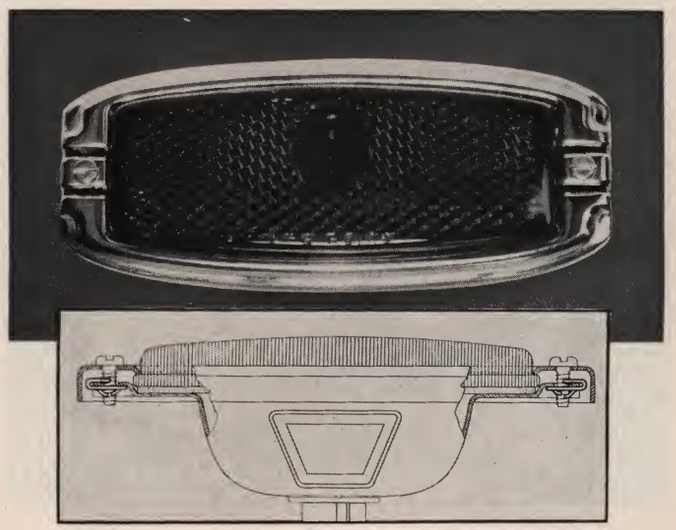
"J" type SPEED NUTS are used by many refrigerator companies to fasten breaker strips to doors and door linings. They are slipped over the edge of the flanges, the extrusion in lower leg of SPEED NUT snaps into register with bolt holes. They eliminate tapped strips, and with their short lower legs, permit a perfect seal by preventing a gap between the assembled parts.



In the assembly of automobiles, scores of "J" type SPEED NUTS are used to fasten head lamps, rear stone deflectors, radiator cores and supports, hood top braces, fender grilles and braces, hood hinges, fender aprons, ignition coils, fender filler plates, radiator grilles and shields, lamp lenses, etc. When threaded nuts are permanently fastened on auto parts, the threads become clogged when parts are painted. SPEED NUTS have no "threads" to clog.

In electric range assembly, "J" type SPEED NUTS are used in heavy duty applications. Here the one piece top and splasher are fastened firmly, but resiliently, to the end panel. SPEED NUTS of this type are also used to fasten the range base to the crate bottom.



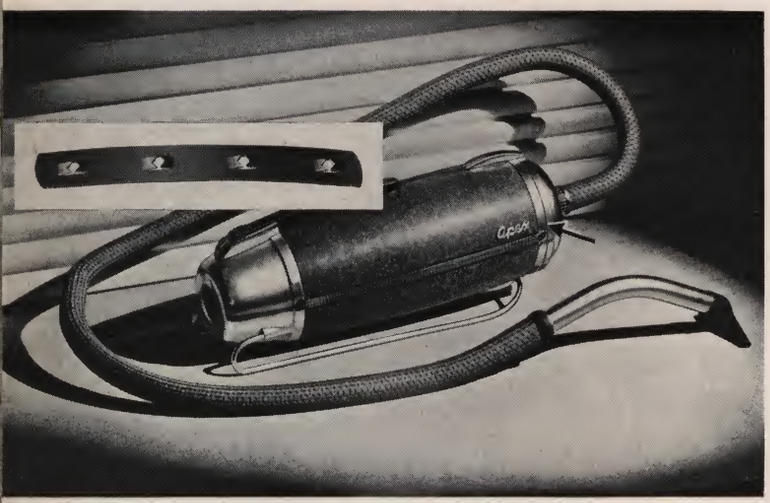


In tail lamp construction, "J" type SPEED NUTS are used to eliminate riveted or welded cage nuts, tapped plates, etc. Their resiliency prevents glass breakage and insures permanent fastening under most severe vibration.

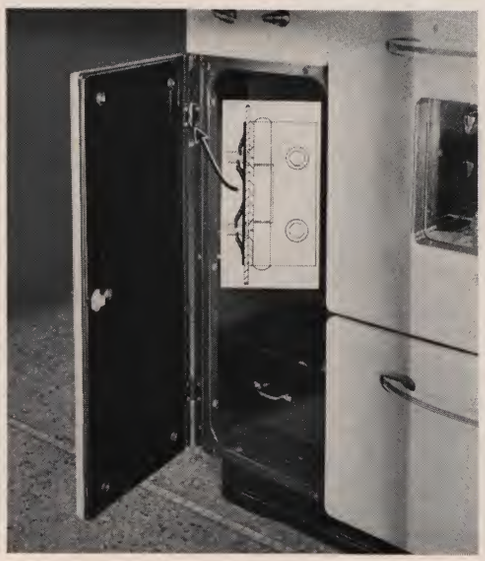
Speed Nuts

IN STRIPS TO COMBINE MANY FASTENINGS INTO ONE

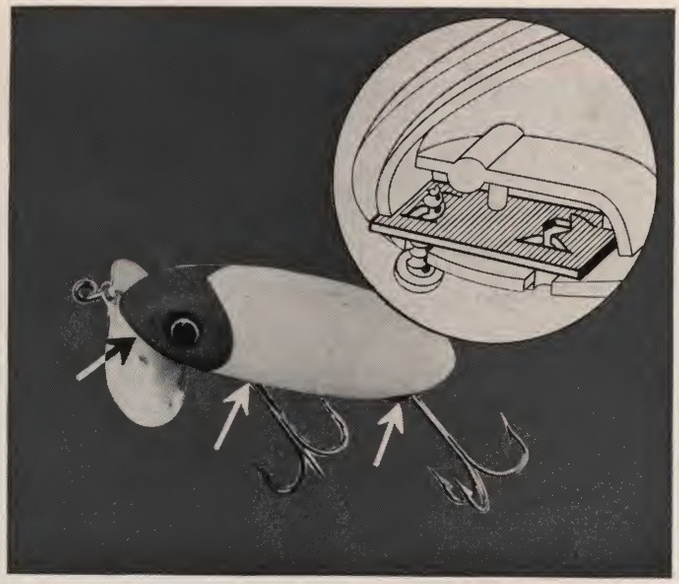




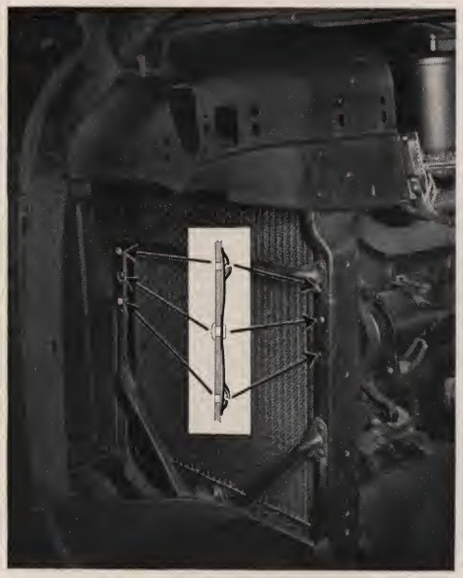
A single SPEED NUT holds all 4 integral studs to fasten vacuum cleaner name plate. This provides 4 fastenings in one with a single assembly operation. Multiple SPEED NUTS with evenly spaced prongs may be had in continuous coils and cut off to desired length.



Cooking range illustrated has a twin SPEED NUT fastening the door hinges. It reinforces the door to prevent sag and consequent enamel damage. Eliminates drilled and tapped plates, affords a firmer spring tension grip, reduces assembly cost and is adaptable to all types of sheet metal cabinet structures.



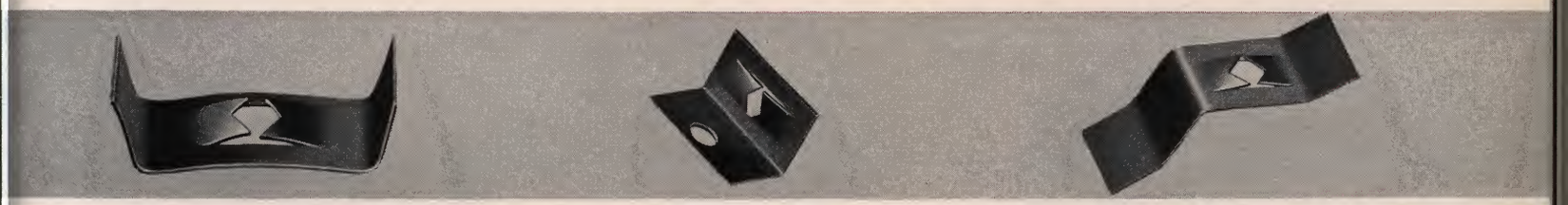
The plastic fish lure illustrated is moulded in halves with 3 recesses provided for holding tiny double impression SPEED NUTS. After the SPEED NUTS are inserted, the halves are sealed together with an acetone. The exterior parts are then fastened to the concealed SPEED NUTS with No. 1 wood screws.

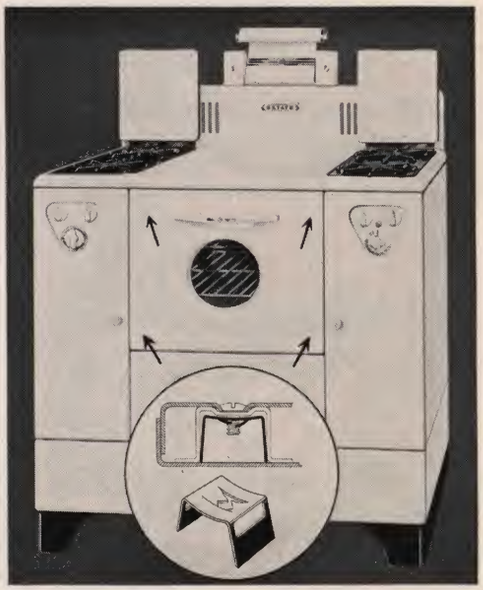


In the automobile assembly illustrated, heavy gauge double impression SPEED NUTS eliminated welded bar nuts. They are riveted in blind location, to the inside of the radiator core support. The fender brace is then fastened to the core support with bolts ($\frac{5}{16}$-10 acme type thread) firmly engaged by the SPEED NUTS for a fool-proof assembly.

Speed Nuts

TO MATCH ANGULAR AND IRREGULAR ASSEMBLIES

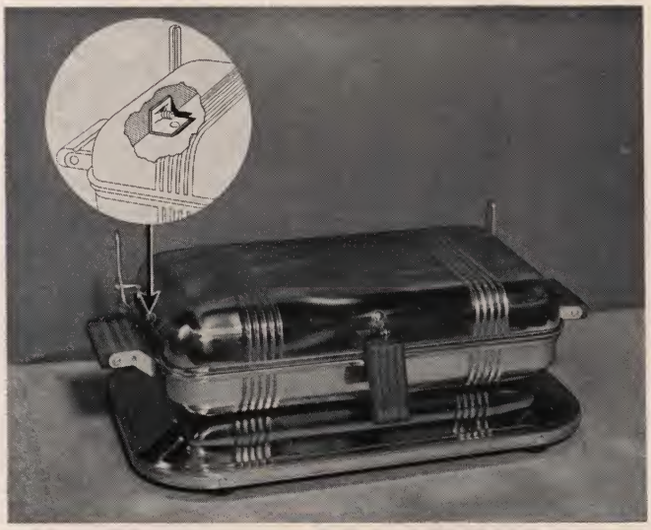




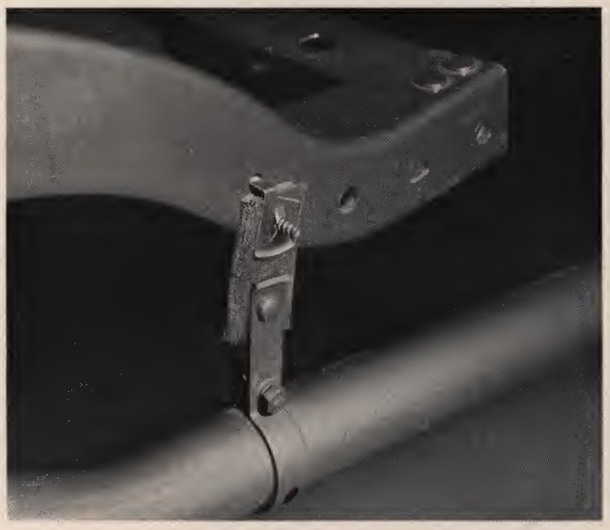
In the construction of the range oven door, SPEED NUT retaining brackets are spot welded to the door panel before enameling. The two spring arms of a "W" type SPEED NUT are slightly compressed and placed into the bracket to stay in bolt receiving position for assembling door panel to lining. SPEED NUTS of this type are made in 3 different depths on the same dies, to accommodate different door thicknesses.



Many different SPEED NUTS are made to bridge difficult angles and radii. Inside the round automobile tail lamp, the SPEED NUT holds the glass lens under spring tension, preventing breakage. The turned down legs prevent endwise movement of lens and hold the SPEED NUT at the right angle to the screw.



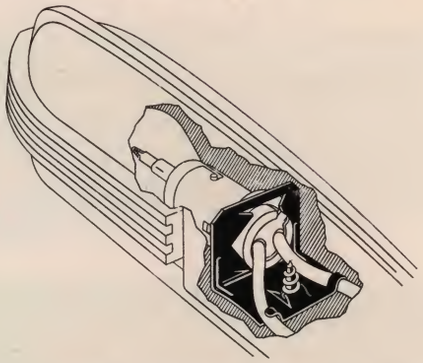
In this electric toaster, angular SPEED NUTS are riveted to the grille plate for blind location assembly. The plate is then positioned in the toaster and fastened with machine screws from the outside. SPEED NUTS of angular and irregular shapes can be made to take the place of several other parts and solve the most difficult assembly problems.



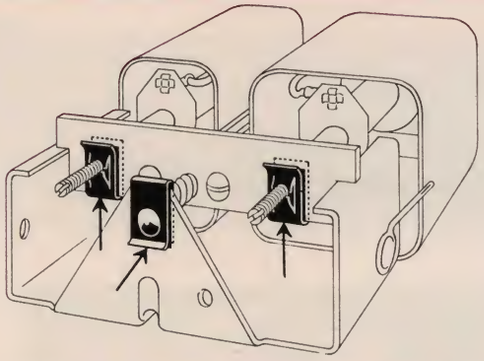
The automobile tail pipe assembly shows how SPEED NUTS can be engineered in unusual shapes to reduce assembly costs. Having a wide bearing surface, this type distributes the fastening load over the fabric strap and eliminates a large washer as well as a lock washer. The struck-down leg engages a hole in the car frame and prevents turning of SPEED NUT in assembly.

Speed Nuts

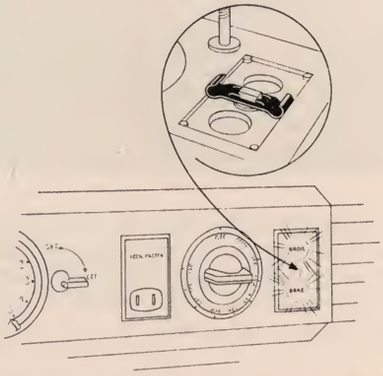
THAT SMASH ASSEMBLY COSTS



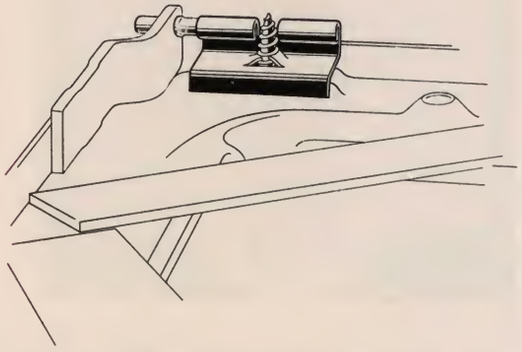
In the assembly of this automobile parking light, one SPEED NUT as an angle bracket, fastens the light socket, spaces the wires and fastens the entire assembly to the base of the light. It eliminates 4 different parts and 3 machining and welding operations.



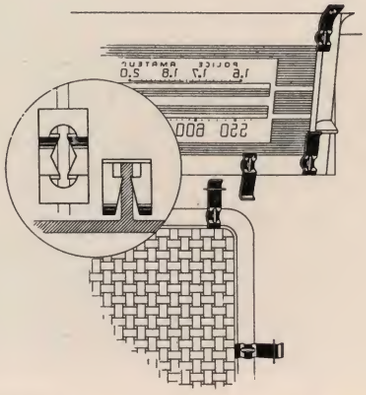
In radio tuning equipment, a "U" shaped SPEED NUT fits over a fibre bracket holding the automatic tuning screw in position. It allows for adjustment of core screw, yet spring prongs hold screw under tension. Special Speed Clip also used as spring thrust washer on drive shaft of tuner.



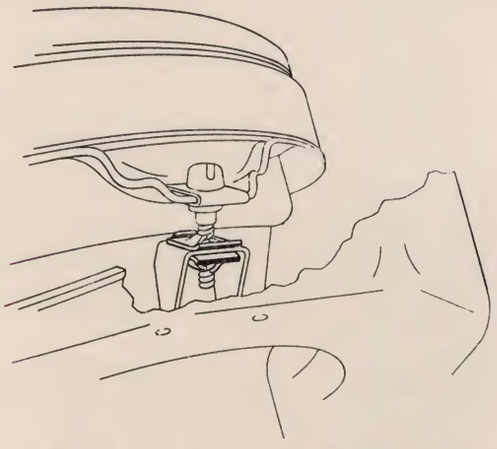
An electric range has a plastic take-out plate serving as lens for pilot lights. A SPEED NUT with 2 spring arms fastens to the integral plastic stud. As plate is snapped into rectangular hole, the SPEED NUT arms spring against back of panel—holding the assembly in place, yet permitting easy removal for replacement of light bulbs.



Here one oven door hinge SPEED NUT saved a leading range manufacturer thousands of dollars annually by replacing a cast and drilled spacer, a machined and hardened plate and a lock washer, as well as drilling and tapping operations. SPEED NUT moves sidewise by sliding bolt in slotted hole. Door may be attached or removed from stove without taking door apart.

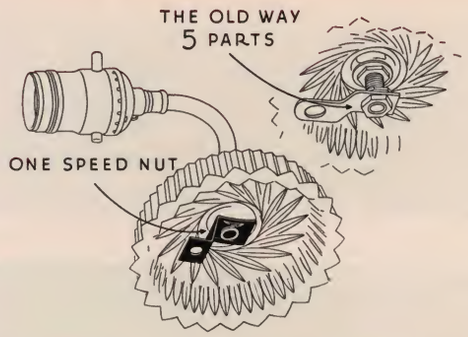


For the first time—a fastening to hold over a moulded plastic rib. Where thin sections of plastics are moulded, studs of greater cross-sectional area than the part itself cause dimples or depressions in the surface. Illustrated are Speed Clips to hold plastic radio bezels in place by fastening directly over reinforcing ribs.

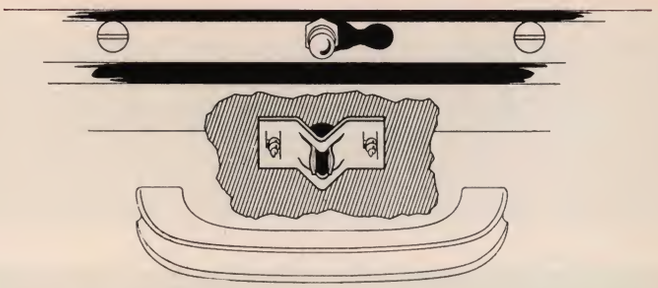


For focusing Sealed Beam head lamps, "U" type SPEED NUTS are used having thread engaging prongs on both sides. After the adjustment screw is threaded through both prongs the SPEED NUT expands as it is pressed over a slotted bracket. This causes a double-locking spring tension grip that holds adjustment permanently under severest vibration conditions at any point throughout the entire threaded length of the screw.

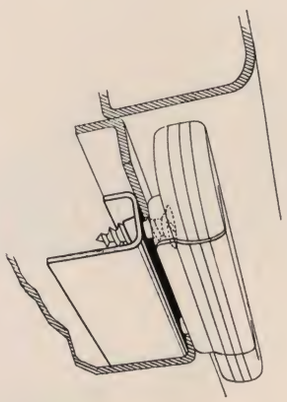
ONE-PIECE DESIGN FOR MULTIPLE FUNCTIONS



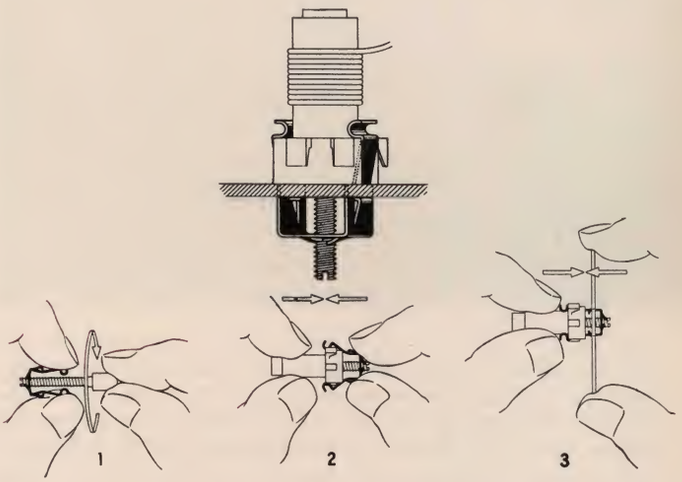
In this novel pin-up lamp assembly a single SPEED NUT replaced 5 other parts. We are constantly engineering special SPEED NUTS to effect assembly savings on all types of products. No charge is made for such engineering development.



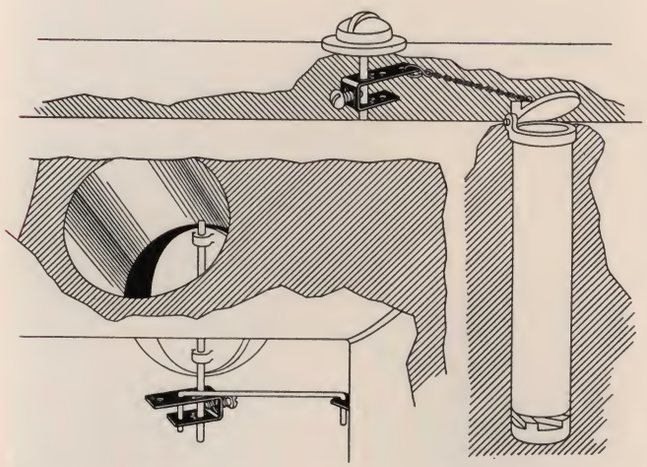
Here a SPEED NUT is the oven door catch on a cooking range. As the door is closed, a ball and stud project through a hole in the lining to engage the curved prongs of the concealed SPEED NUT, which holds the door securely closed.



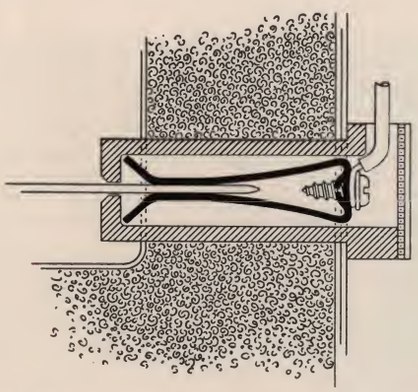
This SPEED NUT fastens hinge to refrigerator door. Replaces tapped strip that was welded to hold in location. The "box" flanges of the door are formed at 90° angles, SPEED NUT is formed over-square and wedges into fixed position under spring tension. Channel shape of SPEED NUT provides reinforcing means at hinging point.



In this radio coil form assembly one SPEED NUT does three jobs. It fastens adjustment screw and core to coil, provides a frictional tension for core screw adjustment and fastens the entire assembly to the radio chassis. Figs. 1, 2 and 3 show assembly stages; compressing ends for screw insertion, clamping SPEED NUT over coil form and snapping the entire assembly into radio chassis.



This SPEED NUT replaces cast lever arm at 1/5 former cost. Used as an adjustable damper yoke on an oil heater, this SPEED NUT clamps securely to a rod as screw is tightened.



Here a SPEED NUT serves as an oven contact clamp in an electric range. Many special types are used in the assembly of electrical apparatus replacing 2 or more parts, as well as being conductors for current. Various terminal connector type SPEED NUTS are also available.

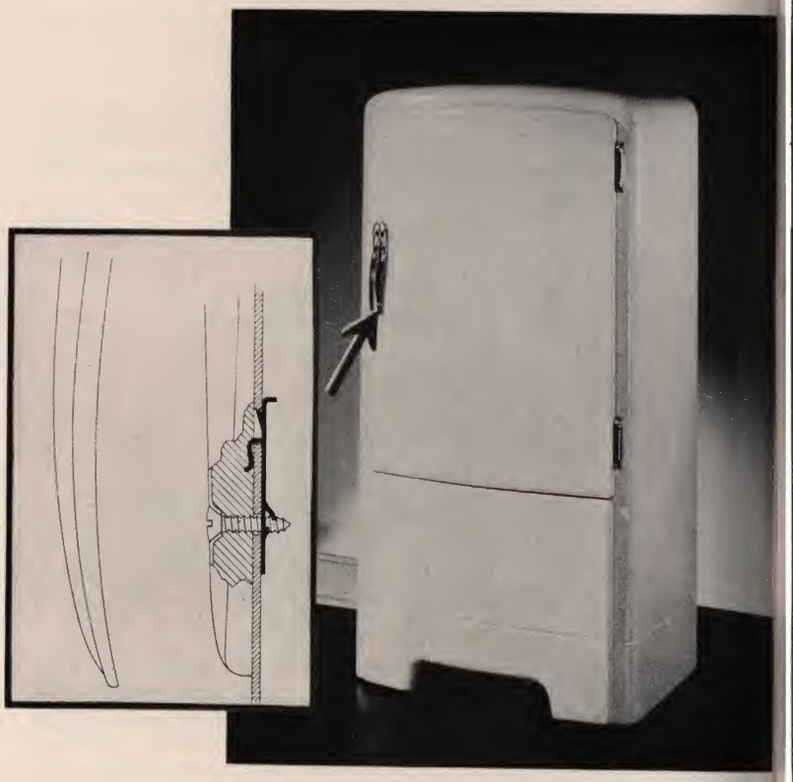
Speed Nuts

TO SNAP INTO MID-SECTIONS OF LARGE PANELS OR SHEETS

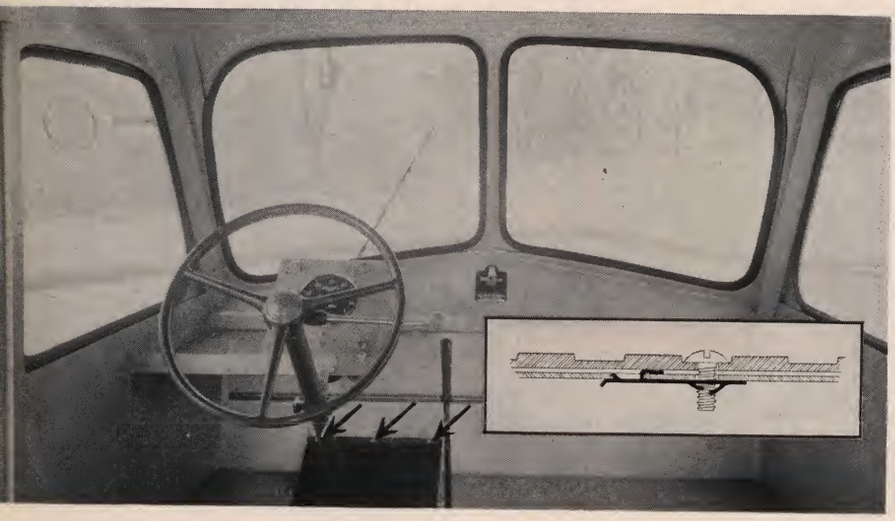




While automobile fenders themselves are not heavy sections, tremendous holding power is required of their fastenings. First, these SPEED NUTS must withstand all sorts of abuses in connection with service replacement of fenders. Secondly, these SPEED NUTS must withstand the tornado-like tightening torque of the power wrenches used on automotive assembly lines. Any one of the 20 or more SPEED NUTS used to hold on the fenders is sufficiently strong to support the entire auto. These SPEED NUTS are snapped into bolt receiving position from the outside of the auto body and self-seal the hole through which they are attached.



This type SPEED NUT fastens the door handle escutcheon on a refrigerator. It eliminated a drilled and tapped plate formerly welded inside the door. Wherever used, this SPEED NUT eliminates clinch nuts, welded cage nuts, or tapped plates, always reducing the number of parts and operations.

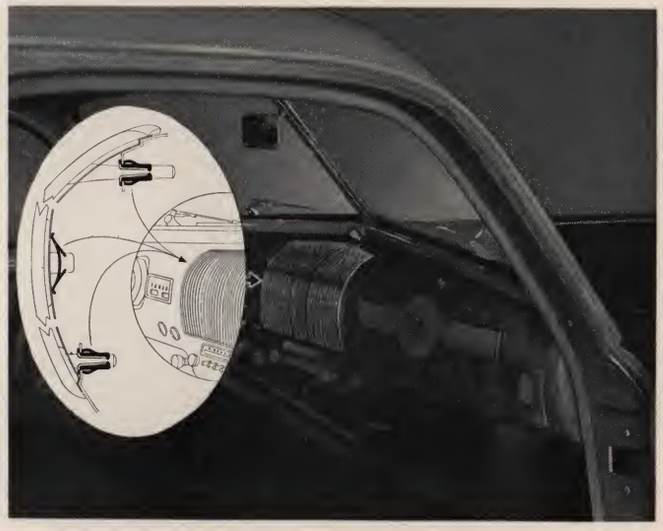


In the delivery truck illustrated, self-retaining SPEED NUTS are snapped into rectangular holes adjacent to bolt holes on the underside of the floor board. The floor mat is then assembled with bolts from top side engaging SPEED NUTS below. This "heel and toe" type is widely used in blind locations where workmen have access to only one side of assembly. Used where bolt hole is too far from edge of part for use of "U" or "J" type SPEED NUTS.

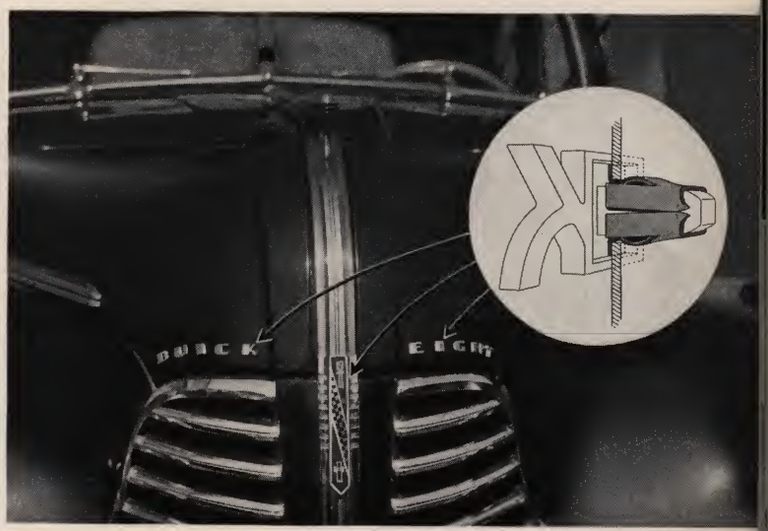
Speed Clips

TO VIRTUALLY "NAIL" PARTS TOGETHER



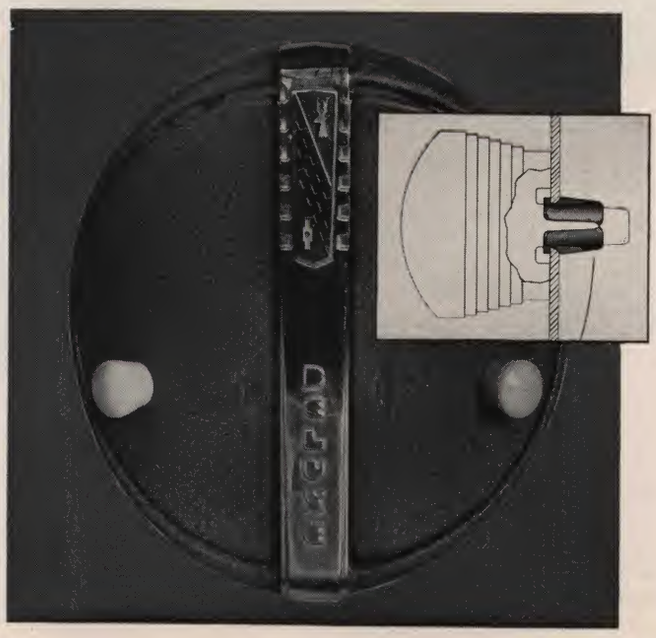


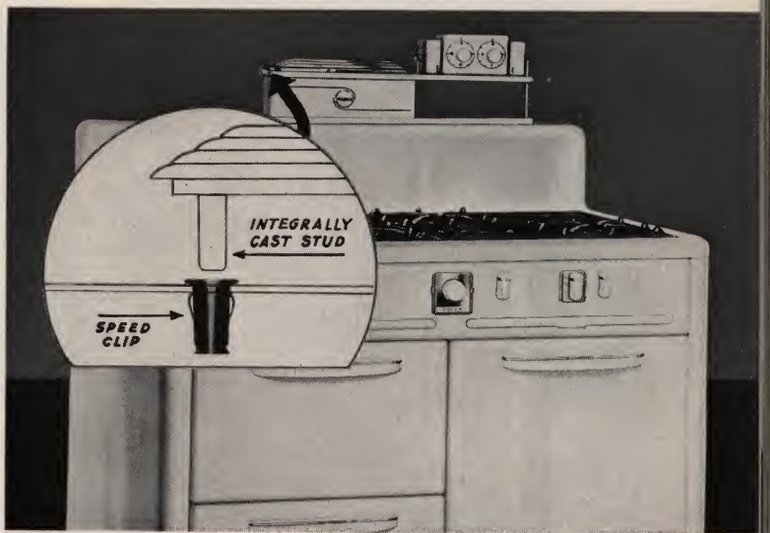
Speed Clips are snapped into holes in this instrument panel. The integral studs of the die-cast grille are then pressed into the Speed Clips, firmly locking the entire assembly. In this assembly a screen is fastened to the radio grille with SPEED NUTS.



By drastically reducing assembly costs, Speed Clips made practical the use of individual die-cast letters for product identification. Here they are pressed over integral die-cast studs and snapped into rectangular holes in panel, to prevent turning. The center emblem indicated is similarly applied, except that round Speed Clip is used as there is no turning problem.

The knobs on this automobile heater have integral plastic studs and are fastened with Speed Clips, that eliminate threaded inserts, simplify moulding and reduce assembly costs. After the Clips are snapped into holes in the heater door, the studs of the knobs are pressed into the Clips. The contractular spring tension of the Clips prevents loosening from vibration and reinforces plastic studs.



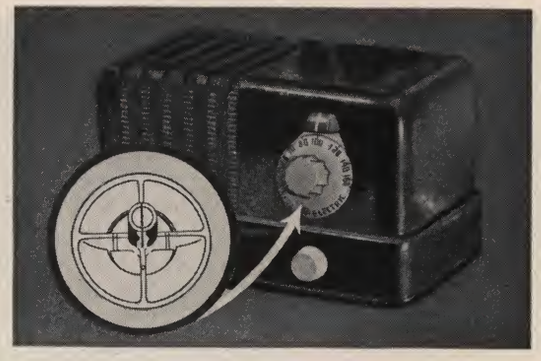


This gas range oven vent grille is fastened with Speed Clips that provide a slidable spring tension for easy attachment and removal. Speed Clips of this type are being widely used for removable assemblies such as take-out plates, inspection panels, toe or kick plates, etc.

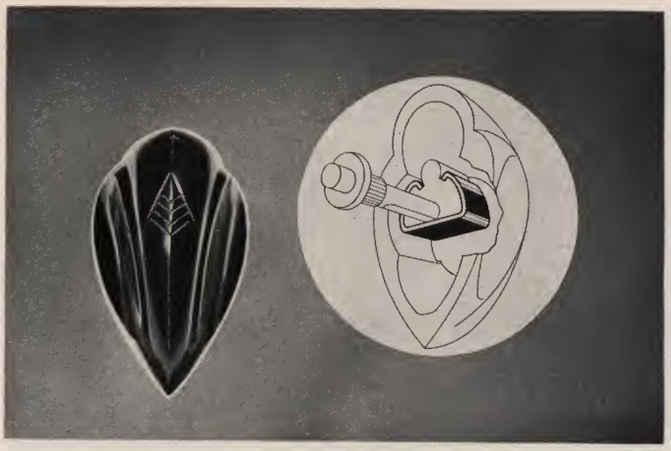
Speed Clips

FOR EVERY TYPE OF KNOB ASSEMBLY

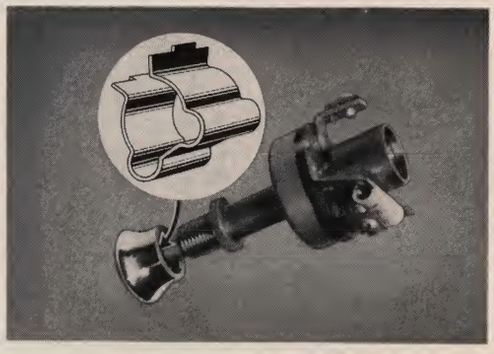




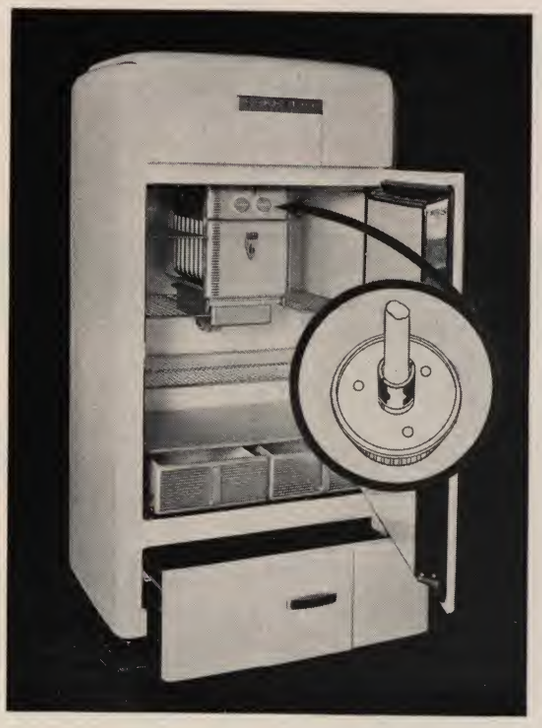
This thermo-plastic radio knob has a split hub that engages the tuning shaft. A Speed Clip which wraps around the hub is first positioned and then the knob is frictionally pressed on the shaft. The spring compression harnesses the cold flow tendency of thermo-plastics and insures a permanent friction fit.



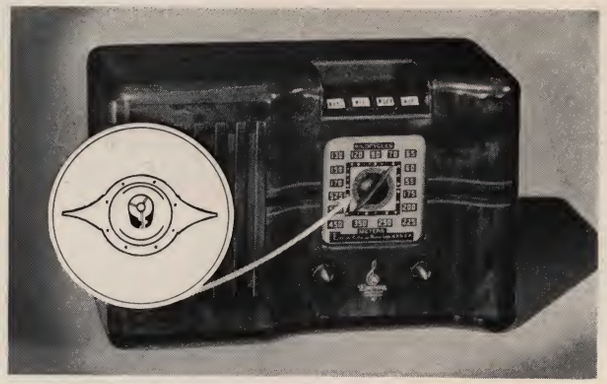
Where hardened or thermo-setting plastic knobs are used, a special Speed Clip is provided. This method allows for a rigid hub portion with one open side over which clip is placed. Speed Clip securely clamps shaft as it is pushed into hub.



Here is another type of Speed Clip for fastening die-cast knobs. Its flat section frictionally engages a "D" shaped shaft. As the shaft is inserted, the clip expands to provide 3 point contact on both shaft and inside of hub.



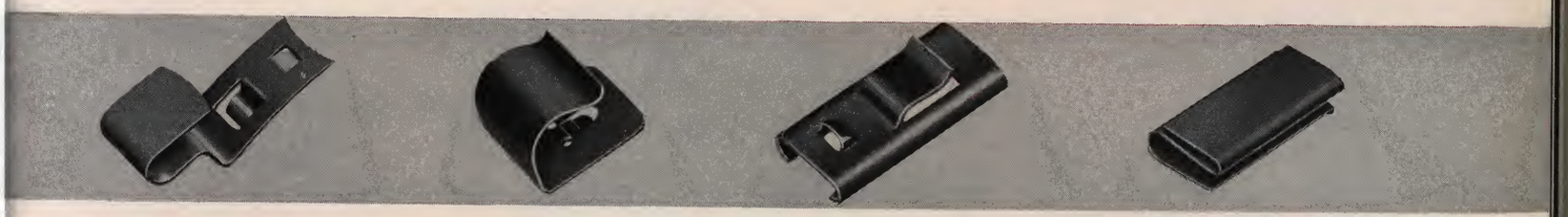
For a plastic refrigerator control knob assembly, another Speed Clip compression ring is used over a split hub. This type of clip saves material by reducing thickness of hub walls. It also eliminates a set screw, and drilling and tapping operations.

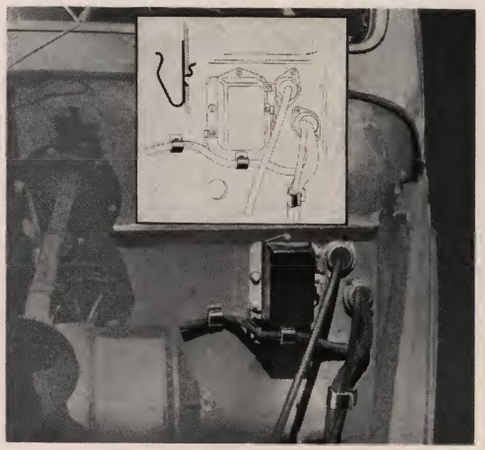


This radio dial pointer assembly shows another use of Speed Clips in fastening thermo-plastic parts. Split-hub Speed Clip assemblies can be used on "D" shaped, serrated, grooved or flat shafts.

Speed Clips

TO "LOCK" TUBES, CABLES MOULDINGS AND PANELS





Various types and sizes of wires, rods, conduit and cables are fastened with Speed Clips. To attach, merely place clip over hole and push sidewise until locking catch snaps into place. In this illustration they are snapped into round holes in an automobile engine dash. Cables are then snapped into the spring arms of the Clips which eliminate special brackets or hangers. Quick and easy to apply, these Speed Clip clamps are strong and vibration-proof.



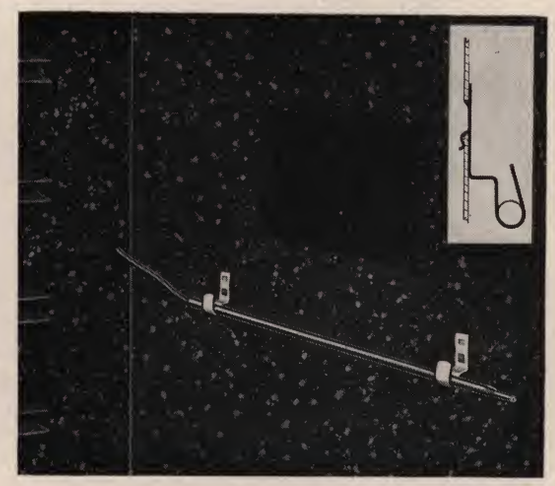
In architectural porcelain structures, Speed Clips afford a panel fastening means that prevents damage from temperature changes, permits replacement of panels and are applied in less time. The panels hang at the top on integrally sheared hooks of the firring strip and the bottom flanges snap over the spring arms of the Clips.



Range clip for assembling top and end panels to main front. Provides spring cushion and prevents chipping or crazing from expansion or strains in transportation and handling. Eliminates holes in flanges of panels. Clips are first frictionally clamped to front frame and panels are slipped into retaining arm of clip.



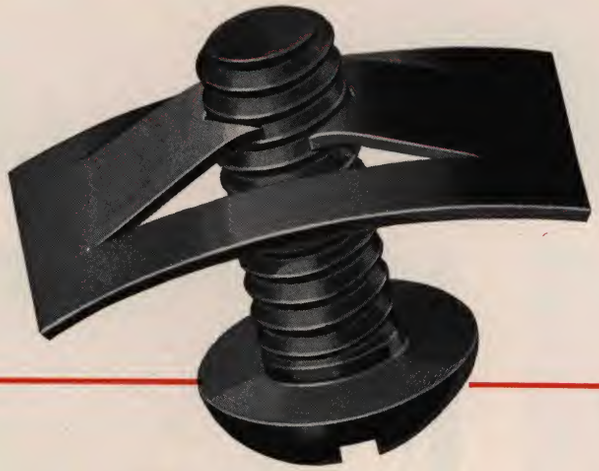
For assembly of mouldings and trim strips, Speed Clips are locked into holes in steel panels. The moulding is then snapped over the spring arms of the clip. This "heel and toe" type fastening is used on Speed Clips of many types.



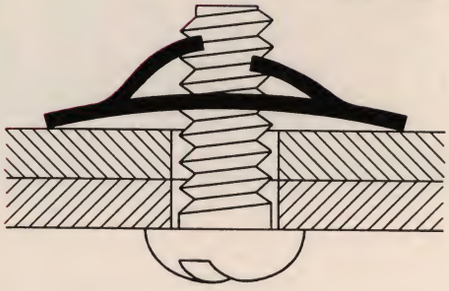
Stove companies use Speed Clips as a resilient fastening for thermostat bulbs. The Clips are simply snapped into round holes in oven liners and eliminate bolts, screws and brackets. The thermostat bulbs are then snapped into the spring arms of the clips—avoiding bending trouble and consequent damage.

Speed Nut System

REPLACES THREADED NUT AND LOCK WASHER



The SPEED NUT is the only one-piece fastening device ever developed that actually affords a double lock.

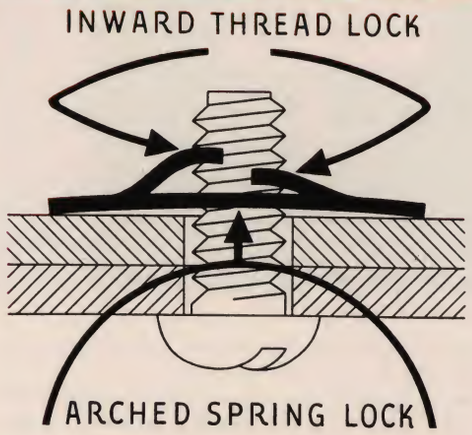


STARTING POSITION

Note, in the starting position, how the arched prongs fit into the threads while the main base of the SPEED NUT is well arched.

●

As the bolt is turned and tightened, the main arch of the SPEED NUT is brought down and the prongs are forced deeper into the roots of the threads to double-locked position.



DOUBLE-LOCKED POSITION

This gives an arched spring lock and an inward thread lock at the same time. Vibration tests have shown that the SPEED NUT will stand from three to six times more vibration than conventional nuts, without loosening. That is why we say SPEED NUTS definitely prevent loosening from vibration and hold assembled parts together under firm spring tension for the life of the product.

The spring tension principle of fastening as developed and pioneered by this organization has received world wide acceptance by manufacturers large and small in nearly every industry.

From the manufacturing of heavy trucks and automobiles to the building of toys and jewel cases, there is a SPEED NUT or Speed Clip that will invariably do the assembly job better and at lower cost. Every SPEED NUT always replaces two or more parts and provides a double-locking, vibration-proof assembly.

We are thankful for the splendid reception our new fastening developments have received and we shall keep our vision constantly on *new* horizons that we may be able to be of even greater service in the future.

TINNERMAN PRODUCTS, INC. ★ CLEVELAND, OHIO, U. S. A.

IN CANADA: Wallace Barnes Co., Ltd., Hamilton, Ontario

IN ENGLAND: Simmonds Aerocessories, Ltd., London

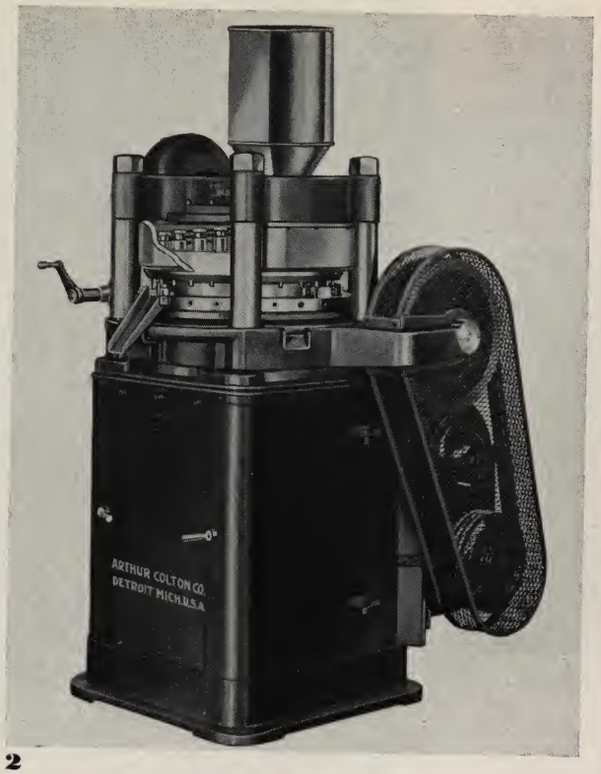
IN FRANCE: Aerocessoires, S. A., Paris

OVER 900 MILLION ALREADY USED—OVER 700 SHAPES AND SIZES

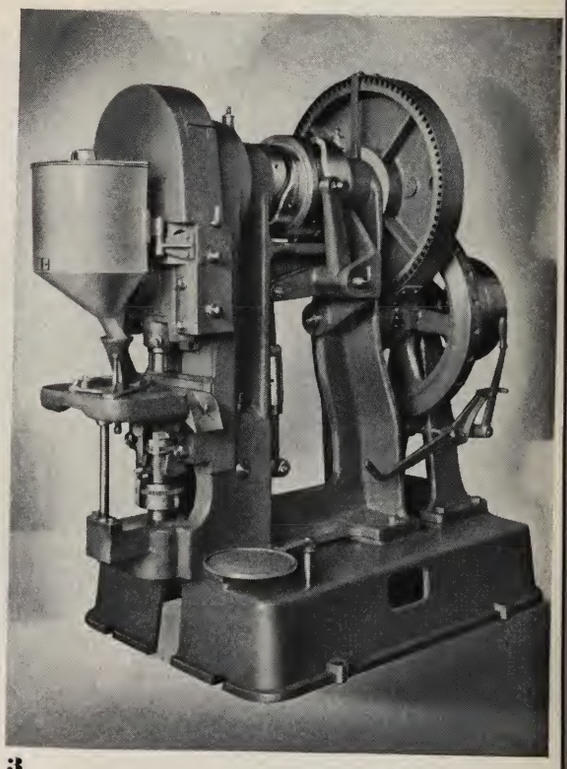
Form No. 135—940 CAC

Printed in U. S. A.

2—Rotary type automatic preforming press, capable of producing from 350 to 750 preform tablets per minute. Equipped with variable speed units for adjusting to various compounds. 3—Single punch tablet machine extensively used for making many preforms of varied sizes. (Photos, courtesy Arthur Colton Co.)



2



3

factor that tends to increase the use of preforms for a greater variety of work is the ever-present desire to reduce molding costs. One effective means to accomplish this purpose is to preheat the preforms before they are placed in the mold, thus further reducing the time required for plasticizing and speeding up press operation and output. Preheating is readily accomplished in ovens or on hot plates. It helps lower labor costs, reduces the length of time the press and mold are used to produce the required volume of parts, and in some instances makes it possible to use smaller presses and molds with a smaller number of cavities.

Ball preform advantageous

The ball preform is ideal for preheating. It is easily rolled through a heated tube and loaded into the hot mold and it has the decided advantage, when used in multiple, of crushing to powder in the press, so that there is no dividing line to show where the several preforms flowed together. It is cheaply made with round dies and inexpensive punches. And in making certain types of moldings a number of these inexpensive small balls can be satisfactorily substituted for a single large ball or shaped preform.

Shaped preforms necessary sometimes

Shaped preforms, notwithstanding the added cost of the die sets required to produce them, are economical in many cases and a necessity in some. The various shapes that can be made sometimes turn an impractical or impossible molding job into a routine operation. The material plasticizes and flows more readily in the mold when the preform shape conforms to that of the molded piece. This in turn insures faster and more uniform cure and, because of better distribution of material, tends to prevent the formation of hidden blisters and improper or insufficient curing which would affect the physical properties of the molding.

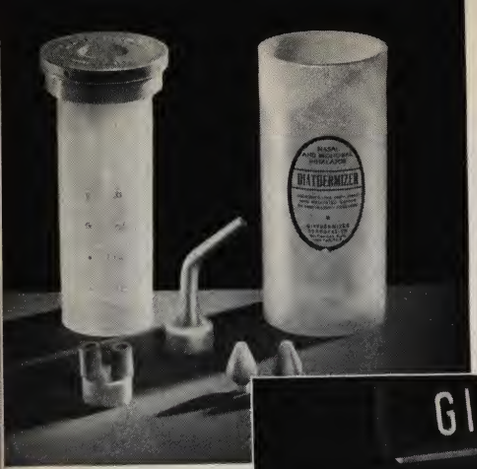
Two types of preform presses

There are two distinct types of presses for preforming work; single-punch presses and rotary-type presses which carry a number of pairs of punches and dies and have considerably higher production. The single-punch type is satisfactory for general work where production is limited or where a number of special shapes or large-size pieces are involved. Rotary presses are primarily production machines for making preforms at 200 to 600 per minute. However, they are being used economically on limited production by operating the press with as few pairs of punches and dies as the job requires. Thus the die cost, a factor to be considered, is kept down, while retaining the advantages of greater speed and reserve capacity.

The choice of a preforming press depends upon the maximum diameter or the diagonal of the piece to be made, its thickness or weight and the production desired. In other words, the larger the preform, the larger and more expensive must be the preforming press to produce it.

Presses built especially for preforming

Presses now on the market were developed especially for preforming purposes. They are rugged, fast and powerful, with safety mechanisms to prevent overload-

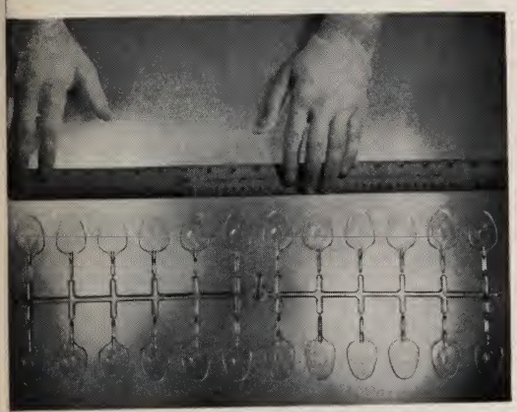


These are typical examples of molded parts being produced on Watson-Stillman Injection Molding Machines.

The Diathermizer, consisting of five parts, molded by Allied Plastics Corp., Los Angeles, California.



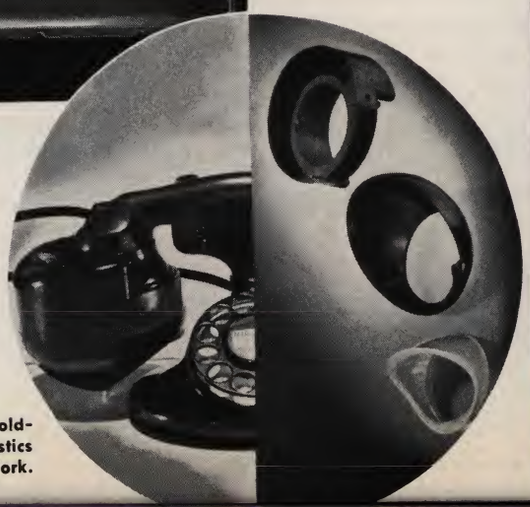
Colorvision letters molded by Tech-Art Plastics Company, New York.



Medicinal Teaspoons molded by Owens-Illinois Glass Co., Closure and Plastics Div., Toledo, Ohio.



Instrument panel assembly for one of the popular 1941 cars molded by Norton Laboratories, Lockport, N. Y.



Silentfone parts molded by Tech-Art Plastics Company, New York.

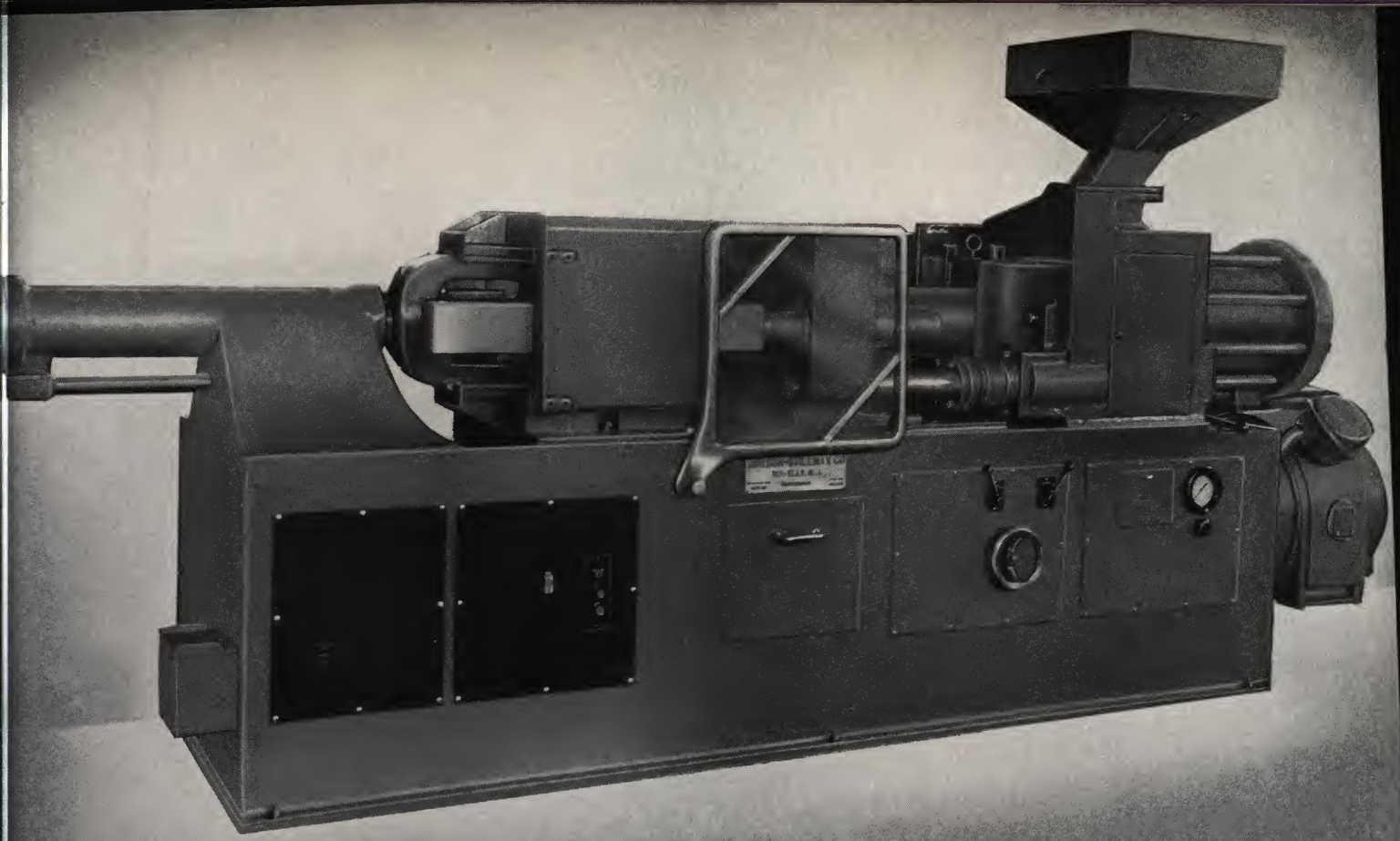
MOLDING PRESSES

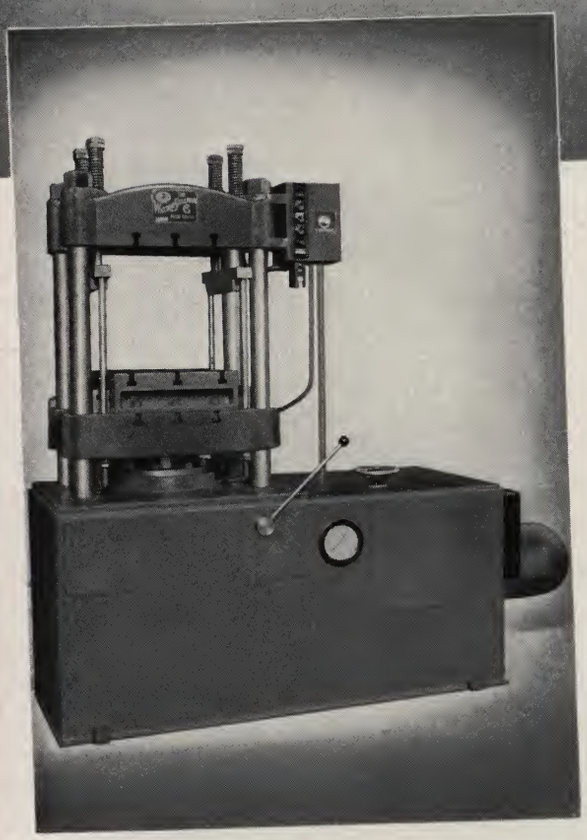
THAT ARE

Engineered to the Job

QUALITY PRODUCTION
ECONOMICAL OPERATION
EXCLUSIVE FEATURES

. . . These are the present day demands of custom molders and manufacturers. Watson-Stillman meets these demands with a complete line of molding presses, built upon advanced engineering principals . . . and upon years of experience with molding problems. • Any W-S press you choose will fulfill your requirements for speed, accuracy and economical operation. • For injection molding Watson-Stillman offers Automatic Injection Molding Machines in 2, 6, 8, 12 and 16 ounce capacities — machines that have set new standards in adaptability, quality and lower costs. • For compression molding there are plain, semi-automatic and fully automatic presses . . . angle molding and multiple platen presses . . . a type for every kind of molding operation. • Whatever your production requirements may be, Watson-Stillman can provide the press to meet your specifications. For further information, write to THE WATSON-STILLMAN CO., ROSELLE, N. J.

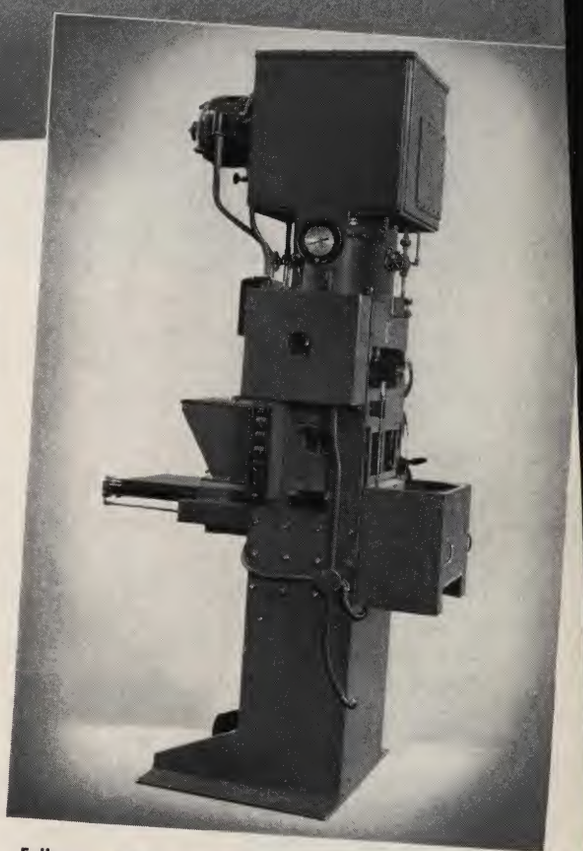




This 80 ton semi-automatic molding press is a complete self-contained unit. Presses of this type are available in a wide range of sizes.

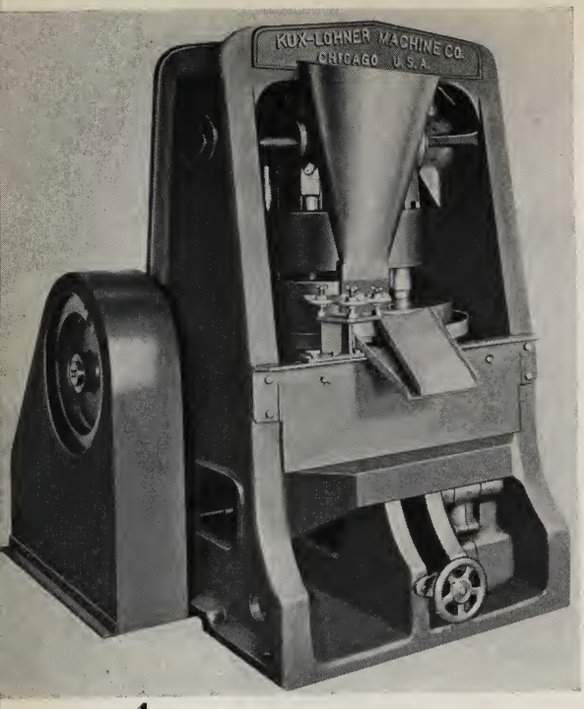
Watson-Stillman Injection Molding Machines have many exclusive features... zone heat control, positive clamping, rapid die and heating cylinder changes, adapter type nozzle — to name but a few.

This 12A twelve oz. model is one of a complete line including standard models in 1½ to 16 oz. capacities.

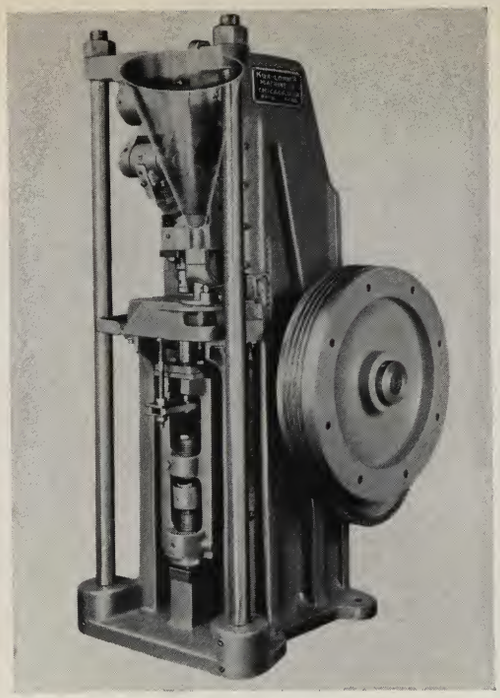


Fully automatic compression molding machines of the type shown above are built in 25, 50 and 75 ton capacities.

WATSON-STILLMAN



4



5

4—Heavy duty rotary press for making preform tablets as large as 3½ in. in diameter. Turret is a one-piece casting with ample bearing surface for the punches. It is driven by a bronze worm. 5—Sturdy single punch type preforming unit for producing solid, hard tablets of 3 in. diameter. (Photos, courtesy, Kux-Lohner Machine Co.)

ing and jamming. They are built to withstand the hard usage of unskilled or semi-skilled operation for three shifts per day and to insure an uninterrupted flow of work from the preforming department.

The demand for harder preforms and operation of machines at maximum pressures has been met by manufacturers with continuous improvements in design and construction. Various devices have been developed to overcome overloading which might cause the press to jam. One manufacturer has developed an automatic excess pressure release, built into each machine, that absorbs and spills the overload without disrupting production. This device can be adjusted to meet varying pressure conditions while the press is in operation, and will even prevent jamming or stalling on centers should a portion of a previously made preform or some foreign substance in the molding powder be charged into the preform die.

Variable speed drive

Variable speed drive soon pays for itself by increasing production on certain sizes of preforms or with different molding compounds. Some molding compounds also have a tendency to laminate because of the air trapped in them, and a slower pressure or longer *dwell* helps make preforms which otherwise would be impossible. A *Speed Change* is most helpful in such circumstances in that it permits maximum production rather than a lower fixed production which must take care of all conditions. It also frequently enables a machine to *pill* materials which otherwise could not be handled.

Care of punches and dies

Proper care of punches and dies is important to successful preforming. Molders who are strong advocates of preforming all emphasize this fact. Worn dies should be corrected so that preforms are ejected without having to pass through narrower diameters than those in which they were formed. The clearance of the lower punch and the design of the relief used in it are important. This relief should be of the sharp-shouldered type made by undercutting on a lathe rather than by grinding the finished punch. Clearance of the upper punch in the die and clearance between the lower punch and the die should always be sufficient to permit air to escape. This is particularly true when urea compounds are used or large preforms are made, otherwise the trapped air will cause laminations in the preforms and necessitate running the press at a low production rate. Shaker shoes, on single-punch presses, should have perfect bearing on the table to insure both proper die loading and prevent excessive spill over the side of the table. Punches should be inspected at intervals and any roughness on the edges should be smoothed down.

With few precautions, and remembering always that unnecessarily hard preforms, inadequate or improper oiling and greasing, and incorrect clearance and relief on punches will all tend to cause needless production delays and repair expense, the user of preform presses should get satisfactory, economical service from his machines for many years of hard, continuous operation.

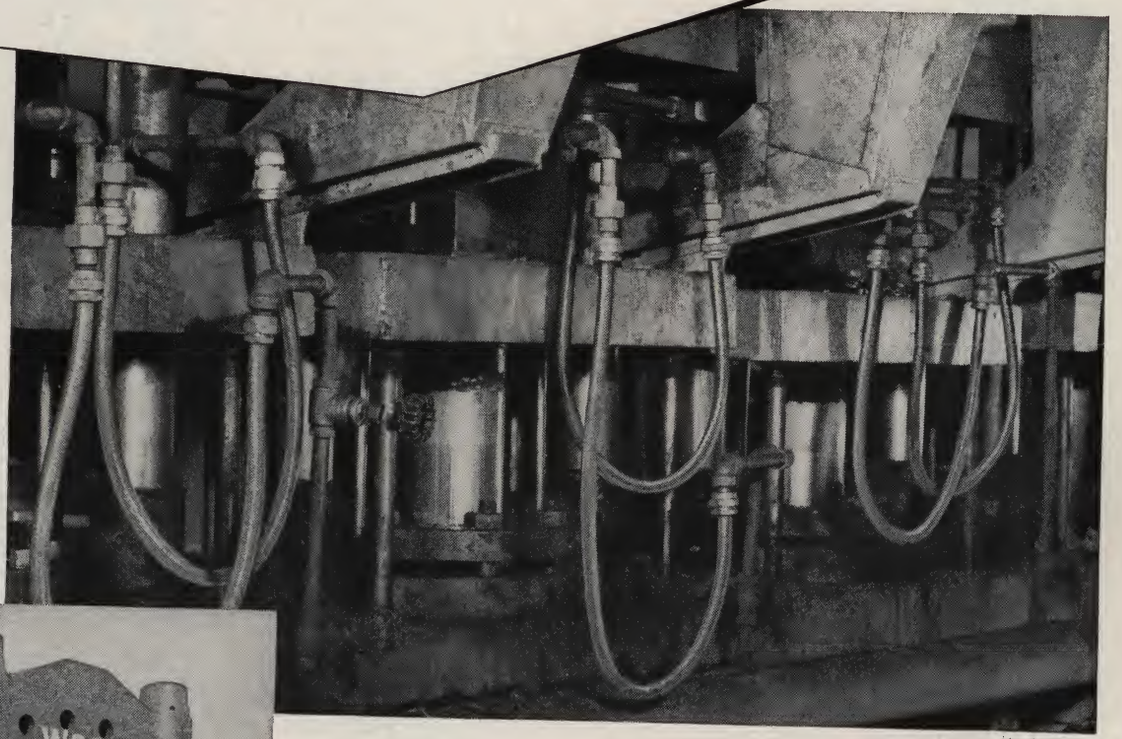
Recent developments

The availability of stronger machines has also enabled molders to preform their tablets much harder, as the new presses apply much more compression pressure than formerly. Harder, stronger tablets have meant less crumbling and less breakage of the tablets while they are being loaded into the molding press. Preforms, also, can now be stored for future use more readily, since the breakage problem has been considerably lessened.

More uniform die filling which assures tablets, all of equal weight; simpler punch, die and core rod mounting to facilitate and speed up punch and die changeovers; new type of cam design for smoother, shockless operation; positive fill and pressure adjustments, are a few of the minor construction changes which have also added to the improvement of today's preform presses.

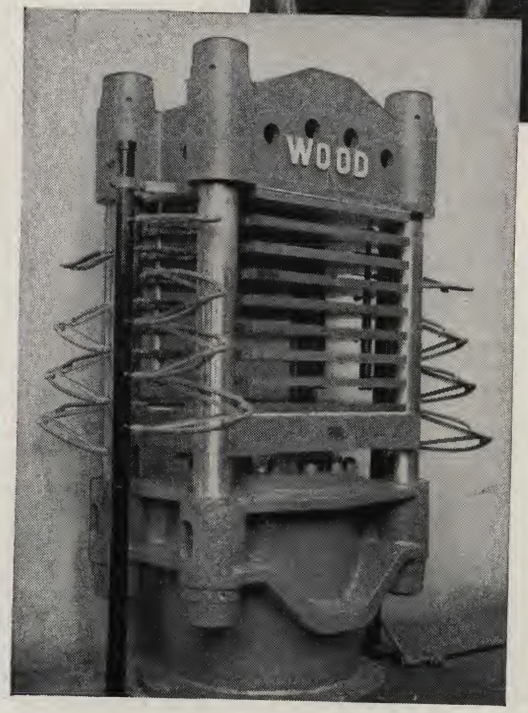
LONGER SERVICE IN EVERY LENGTH OF

American Seamless Flexible Metal Tubing



RIGHT: *American Seamless has been in daily use for over two years in this modern molding plant conveying hot water at 200 lbs. pressure.*

BELOW: *American Bracketubes are shown below on a molding press. A patented support mechanism holds the flexible tubing in horizontal position. Ask for catalog.*

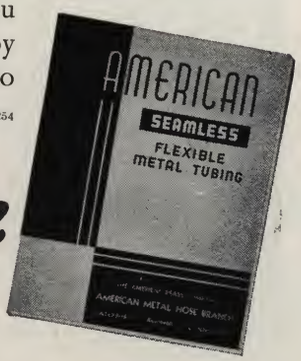


WHEN you buy flexible connectors to carry steam heat or cooling water to the dies or platens on your presses, you really buy *hours of service.* Your costs are materially affected by the number of times the connector will move up and down without needing attention.

No wonder so many plastics molders have standardized on AMERICAN SEAMLESS for this vital service, for American Seamless is made from true bronze seamless tube, corrugated to obtain true flexibility and jacketed with wire braid to impart extra strength. Fittings can be either welded on, or of the "reattachable type."

Let us send you the complete story, including simple installation instructions. We can show you how to get more months of service by using a product especially designed to do the job. Ask for catalog SS-25.

39254



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AMERICAN METAL HOSE BRANCH OF THE AMERICAN BRASS COMPANY
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Compression presses

A COMPRESSION press may be defined as a device which applies pressure to plastic material either in a mold or between plates causing it to be cured to a definite size and shape. The necessary heat may be applied directly to the chanelled mold or indirectly through the steam plates of the press. The simplest form of a press consists of a hydraulic ram and cylinder tied to a resisting member or head by means of four rods. This general design has many variations both as to size and shape. Compression presses have two general divisions as to the type of work done, namely, laminated plastics of the sheet or slab type and, secondly, parts molded to a definite shape.

Laminating presses

These are usually of the multiple opening type having several steam platens between the fixed head at the top and the ram bolster and moving platen at the bottom. The sandwich or layers of impregnated material are placed between the platens and the pressure applied by ram or rams. Steam is passed through the drilled holes in the platens giving the proper heat for curing. Usually suitable loading devices called elevators, are used to raise and lower the material to the proper opening in the press. This type of press, however, because of its special nature represents only a small percentage of the total of compression presses used.

Compression presses for molded parts

These may be classified or divided into several different types, depending upon the nature and quantity of the molded parts to be produced, the principal divisions being:

A. As to operation, including hand-molding, semi-automatic, and fully automatic.

B. As to design, such as rod-type or side-plate-type.

C. As to source of hydraulic pressure, i.e., from a central accumulator or pressure from a self-contained hydraulic pump.

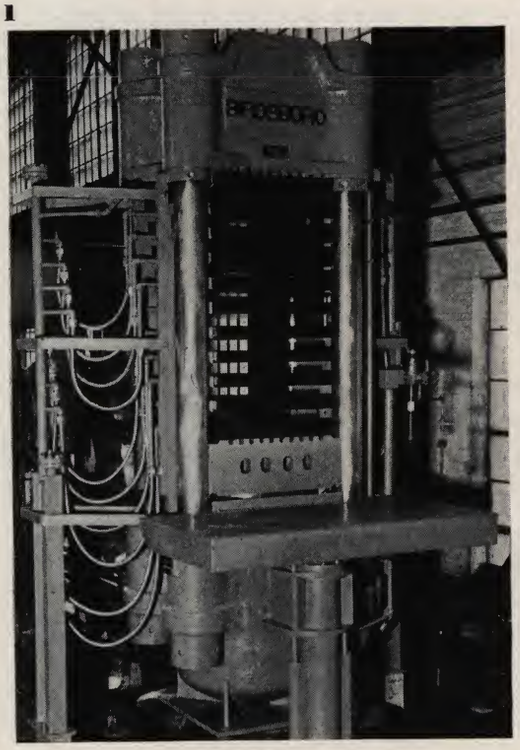
Hand molding presses

These are generally small, not over 20 in. by 20 in. in size and almost entirely of the four rod type. Sometimes they are multiple opening but usually of one opening only. The mold is separate from the press and is loaded and unloaded on the outside and then placed between the steam platens of the press. The heat for the curing of the material passes through the body of the mold from the steam platen. This type of press is used for experimental and laboratory work and for small quantity runs where the cost of a more elaborate multiple cavity mold is not justified.

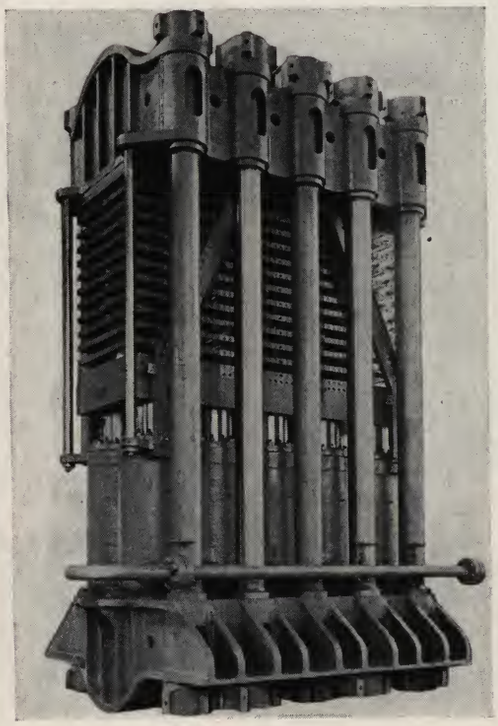
Semi-automatic presses

Perhaps most generally used of all of the compression type, they are almost entirely of the upstroke type ar-

1



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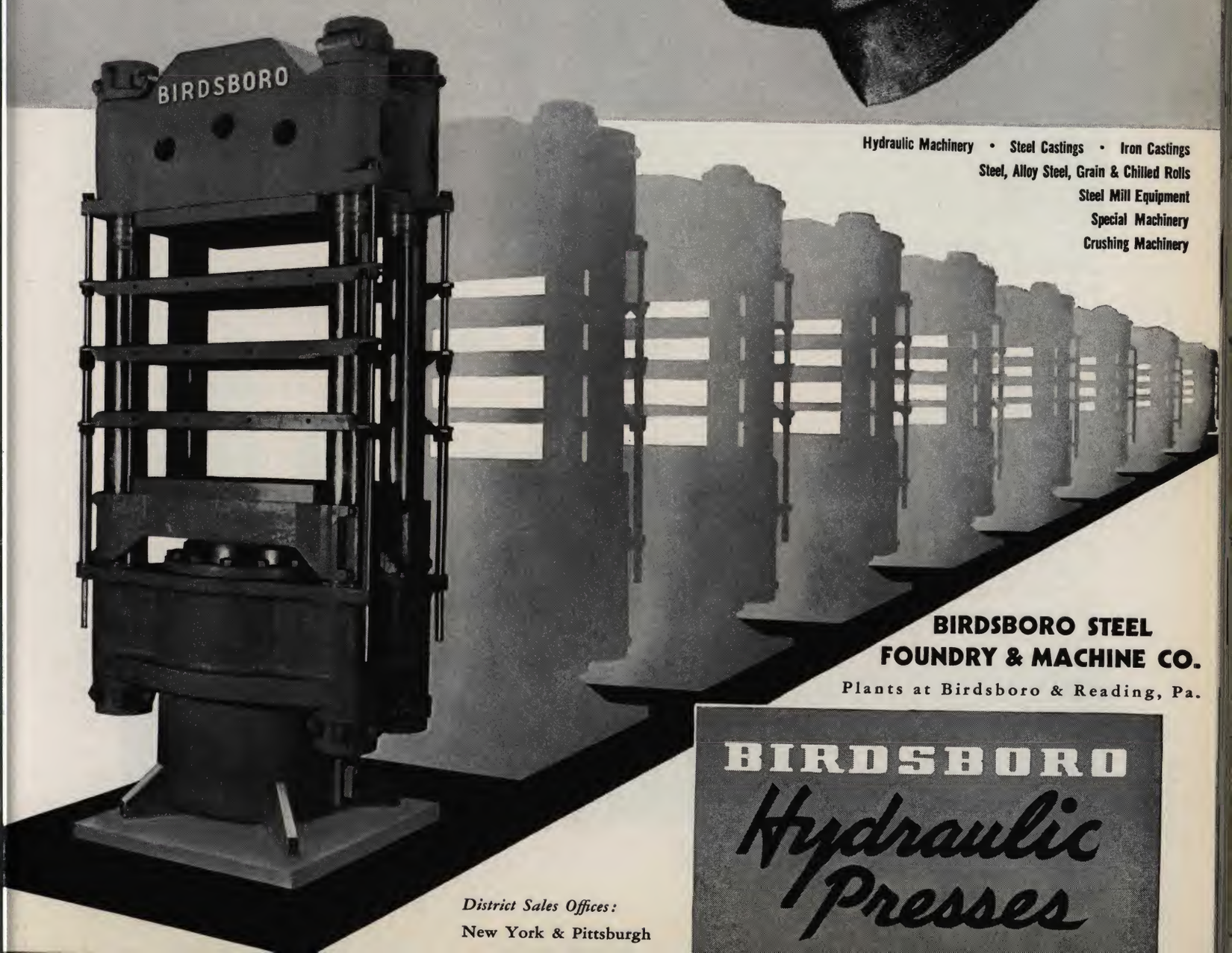
1—Birdsboro 10-platen laminating press equipped with hydraulic rising platform for loading. All platens are equipped for both heating and cooling. 2—Baldwin-Southwark 1000-ton laminating press. Twelve openings are provided for loading

"DID YOU SAY THAT JUST ONE PLANT ALONE HAS 28 BIRDSBORO HYDRAULIC PRESSES?"

"THAT'S RIGHT... IN FACT ALL BUT THE FIRST 4 PRESSES ARE BIRDSBORO'S... STANDARDIZING ON BIRDSBORO GUARANTEES FLEXIBILITY OF OPERATION, THEY SAY"







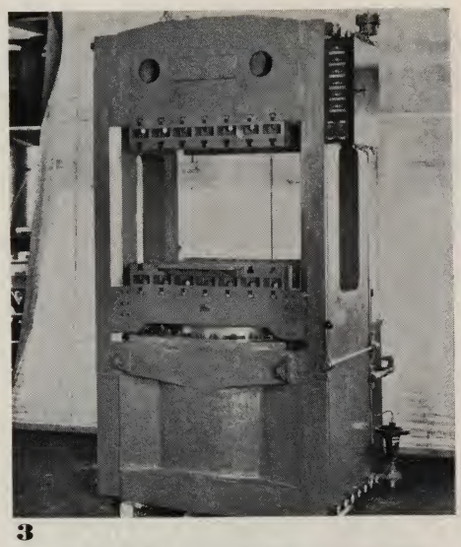
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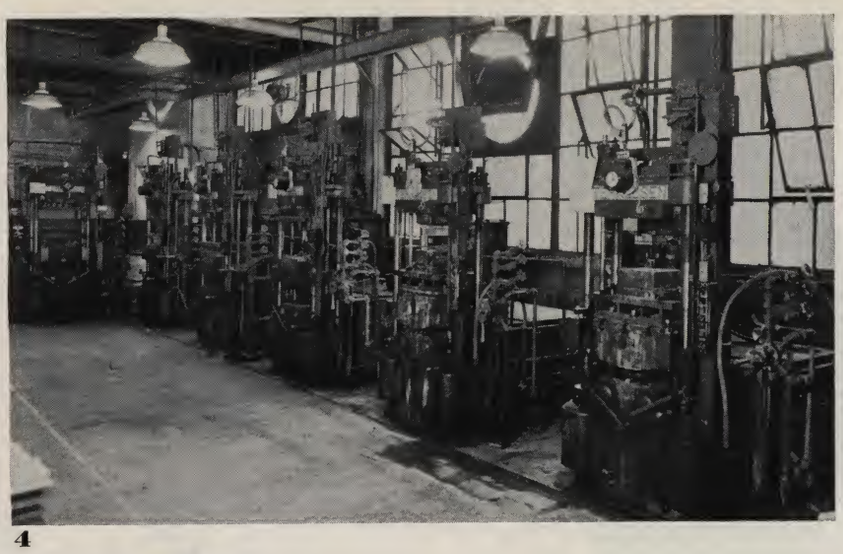
Plants at Birdsboro & Reading, Pa.

BIRDSBORO
Hydraulic Presses

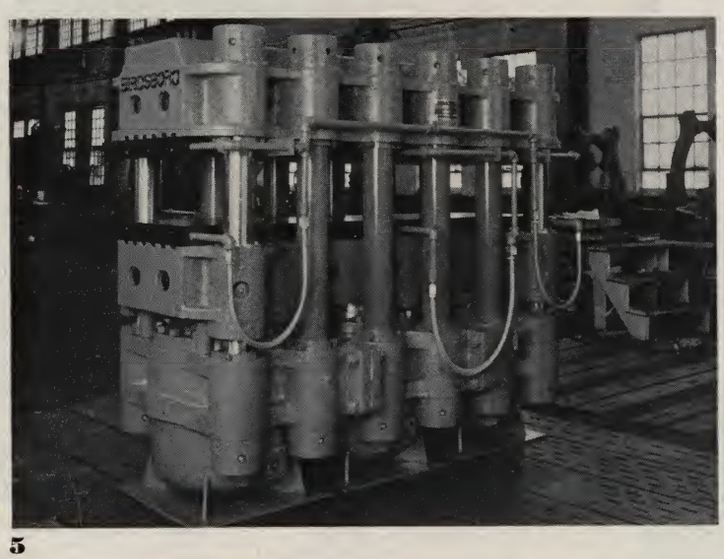
District Sales Offices:
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3



4



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3—French Oil Mill Machinery Co. self-contained 800-ton side plate-constructed compression press, has fully automatic time cycle control. 4—Plant installation of electrically powered electro-draulic presses of Terkelsen Machine Co. Power is consumed only during opening and closing stroke. 5—Birdsboro Steel Foundry and Machine Co. 3-cylinder hydraulic press with 25½ in. by 100 in. platen area

ranged with strippers at the bottom and sometimes at the top for the proper ejection of the finished piece. The two halves of the mold are mounted on bolsters and parallels, so-called, which separate the mold from the platen proper for stripping purposes. The mold itself is arranged with ejector pins which project through the bottom of the mold and bear against suitable cross knockout strips which in turn bear upon the knockout bars of the press. When the press is open, these knockout bars are actuated by means of either auxiliary hydraulic cylinders or by means of knockout pins which bear against the top of the cylinder on the end of the down stroke. A similar arrangement is sometimes provided at the top in order to obtain top stripping as well.

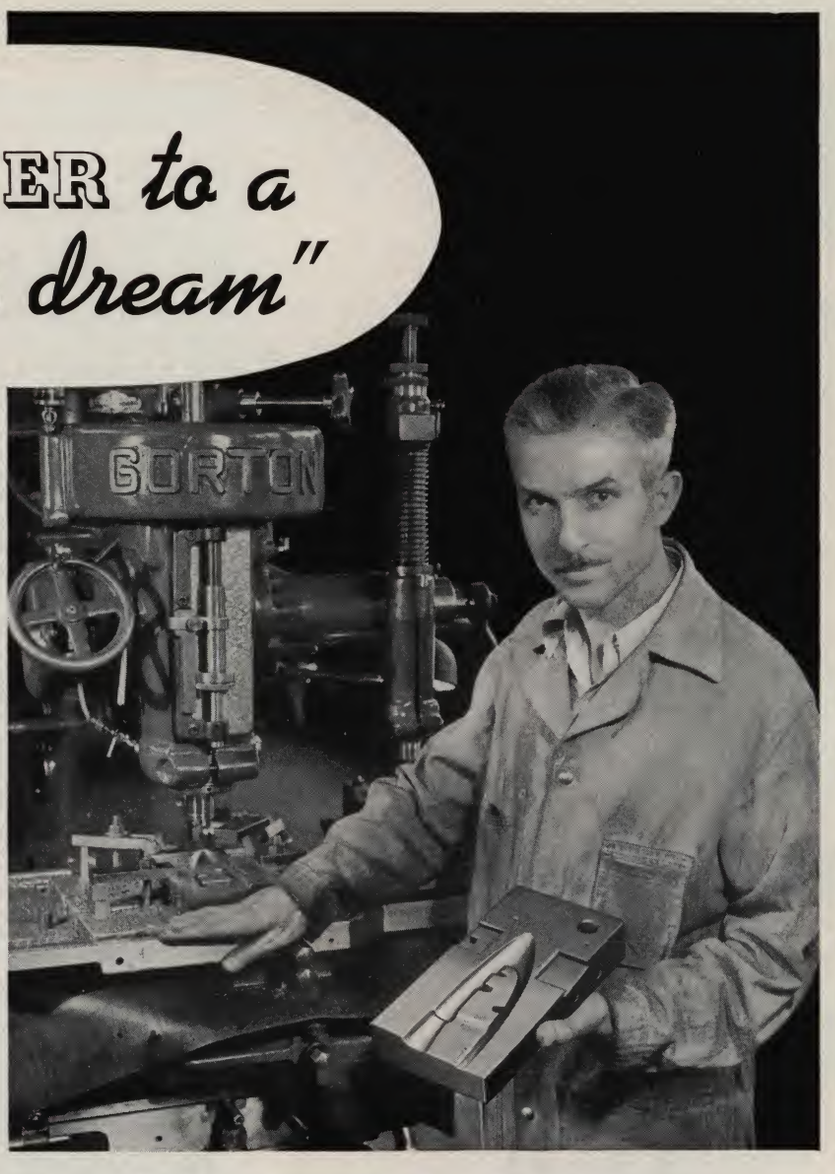
The semi-automatic press is always equipped with pull-back cylinders or other forms of return mechanism as it requires considerable pressure at times to separate the two molds and eject the finished piece.

Automatic presses

These have not only the regular features of the semi-automatic press but also automatic loading and ejection devices so that it is only necessary for the operator to keep the hopper full of the molding material. These automatic molding machines have greatly improved the competitive position of plastics, have made the molding of plastics independent of skilled operators, improved the dielectric strength and physical properties of finished parts by doing away with errors of human omission or commission. They cut flash losses and do away almost entirely with finishing and inspection operations that were formerly necessary. They make it possible to obtain large output from inexpensive single-cavity molds and thus hold the initial mold investment to a point so low it is profitable to mold plastics even in limited quantities and for purposes where they never before have been economical. And because initial mold cost is low it is easy and practicable to change design in an automatically molded product as often as may be advisable and at little expense. Inventories can likewise be kept low. Considerable further development in this type of press is likely in the near future in order to compete with the high production of the injection molding type press used for thermoplastics.

The most outstanding recent development lies in an attachment for automatically unscrewing and ejecting threaded parts. By means of this device, Fig. 12,

"THE ANSWER *to a toolmaker's dream"*



"We called our Gorton Die and Mold Duplicator 'the answer to a toolmaker's dream' when, on the die casting die shown, we were able to save 30 hours, or 75 per cent, over our former methods."

Gorton Duplicators are representative of 18 styles and sizes of machines for the die and mold maker, each of which is the result of over 45 years' experience in producing fine machine tools.

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1. Direct reproduction from masters or models.
2. Accuracy to close tolerances.
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4. Extra range, vertically and laterally.
5. Accurate settings through individually graduated and engraved dials.
6. Fast cutter changes.
7. Spindle speeds to 6,000 R. P. M. are standard.
8. Power or hand feeds, as required.

A FEW OF THE EIGHTEEN GORTON MACHINES FOR DIE AND MOLD CUTTING



SUPER-SPEED MILLING MACHINE
Can be quickly converted into duplicator with addition of duplicator table and tracer arm. 3 sizes.



3-DIMENSIONAL PANTOGRAPH
This machine is designed for modelling and engraving. It is exceedingly sensitive. 2 sizes.



ROLL ENGRAVING MACHINE
2 sizes; for rolls up to 30" dia., and 8 feet long and 12½ feet long. Pantograph construction similar to other GORTON models.



UNIVERSAL MILLING MACHINE
Highly accurate; designed for running small cutters at high speed at any angle.



DIE CUTTING—PROFILING MACHINE
Heavy duty machine for high speed profiling on large flat or spherical surfaces.

GEORGE GORTON MACHINE CO.
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threaded plastic moldings are being produced in a completely automatic operation at production rates of 1000 or more per mold cavity per day. Standard machine threads, internal or external, of any desired pitch, may be molded, the speed of the unscrewing device being readily adjustable to that of the pitch of the thread. Ejection is positive and takes place at the same time the mold is opening. Thus there is no loss of time or lengthening of the molding cycle in producing threaded parts. By mounting separate molds in the machine and changing each mold individually, from one to five threaded moldings can be made simultaneously. Powder feed mechanism, with corresponding numbers of outlets, are provided to charge each cavity with an accurately metered amount of material. The following table illustrates the limiting diameters for caps of varying numbers of cavities—used in both 10 ton and 15 ton models.

*Number of Cavities	10-Ton Press	15-Ton Press
Single	$3\frac{1}{4}$" Max. O.D.	4" Max. O.D.
Double	$2\frac{1}{4}$" " "	$2\frac{3}{4}$" " "
Triple	$1\frac{3}{4}$" " "	$1\frac{3}{4}$" " "
Quadruple	$1\frac{1}{8}$" " "	$1\frac{1}{8}$" " "
Quintuple	$\frac{5}{8}$" " "	$\frac{5}{8}$" " "

* Based on producing conventional threaded caps with soft flow material.

Rod-type molding presses

These usually consist of a ram and cylinder at the bottom tied to a top head by means of four tension rods and nuts. The ram carries a moving platen which is guided on the four tension rods. Both the top platen and the moving platen are arranged with bolsters and parallels as described above having "T" slots for the proper fastening of the two mold halves. Knockout bars are arranged on both sides at the bottom and sometimes at the top to facilitate removal of the part.

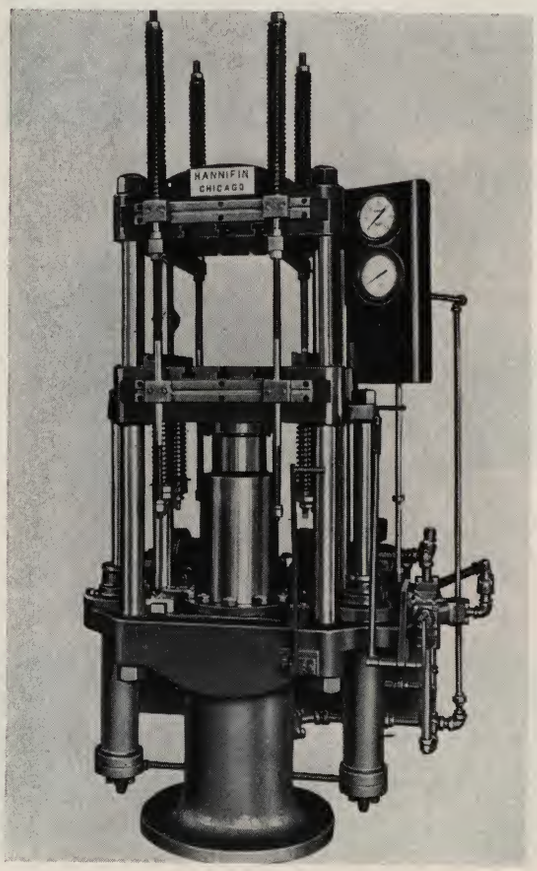
Side-plate type molding presses

This is a more recent development in design which has been occasioned by the demand for greater accuracy in guiding and also for a neater, more streamlined appearance of the press itself. Instead of using four round rods for holding the cylinder to the top head, two rolled steel side plates of homogeneous and uniform material are used. Large substantial keyways are machined in these plates and corresponding keys in the cylinder and top head to take care of the tension. These side plates are securely bolted to the top and bottom members and, if properly designed, present the same effect as a solid housing.

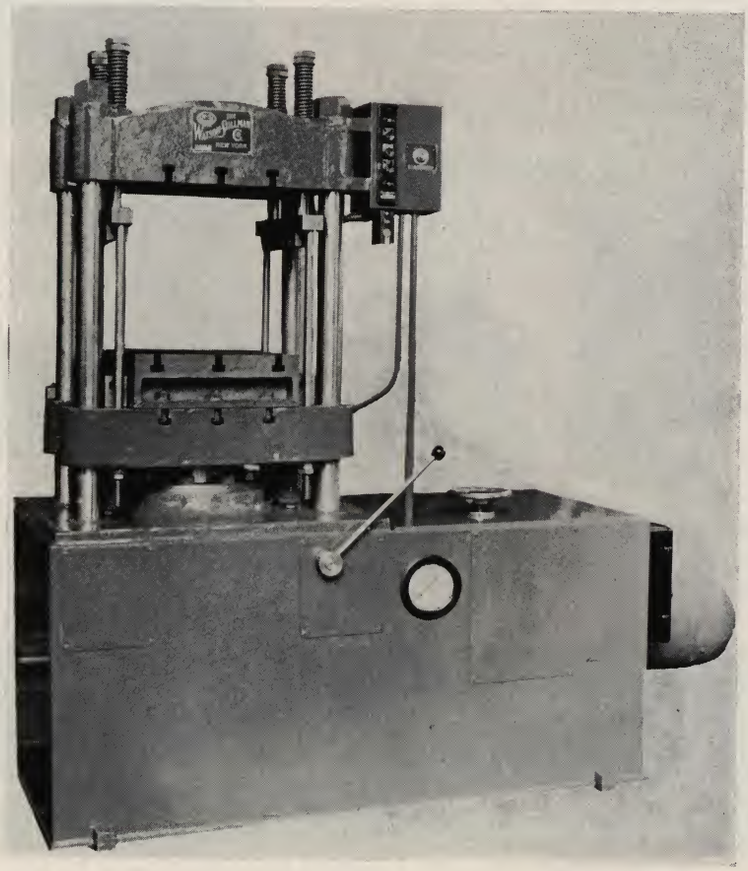
The most valuable characteristic is the use of the gib guides which are fastened to the moving platen and bear

6—Self-contained 125-ton rod-type hydraulic press manufactured by Hannifin Mfg. Co.
7—Watson-Stillman automatic self-contained compression molding press with platens 19 in. by 20 in. Operates under pressure of 2000 lbs. per sq. inch

6



7



WINNERS OF TOP AWARDS AND HONORABLE MENTIONS *SELECT* THE LEADING INJECTION MOLDING MACHINE

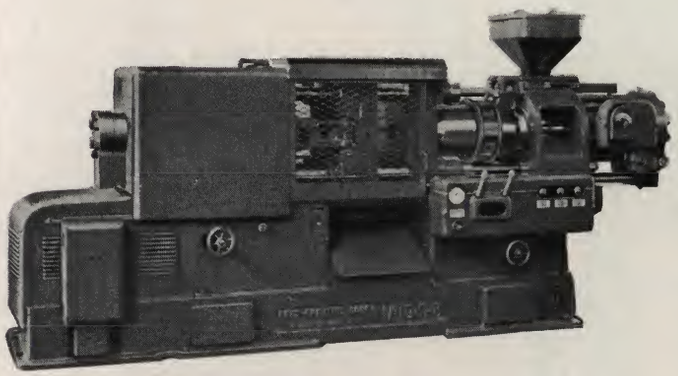
REED-PRENTICE



Above are shown representative award winners molded on Reed-Prentice Injection Molding Machines.

1. Household Group—W
   Rich and France, Inc.—Broom
   Molder: Elmer E. Mills Corp.
2. Transportation Group—W
   Chrysler Instrument Panel
   Molder: Chrysler Corp.
3. Sporting Goods Group—H.M.
   Chicago Musical Instrument Co.
   —Bugles
   Molder: Elmer E. Mills Corp.
4. Miscellaneous Group—H.M.
   Saks and Co.—Celares Line
   Molder: Thomas Mason Co.
5. Transportation Group—H.M.
   S. H. Thomson Mfg. Co.
   Model 5M Mobilite
   Molder: Watertown Mfg. Co.
6. Miscellaneous Group—W
   Tri-Pak Gun Kit Inc.—Oil Can
   Molder: Remler Co. Ltd.

W—Top Award *H.M.—Honorable Mention*



Available in 2, 4, 6, 8 ounce capacities
Reed-Prentice features covered by Patents Pending

Congratulations to all—designers, molders, manufacturers—who contributed so generously to the success of the 1940 Modern Plastics Competition. The recognition accorded the winning concerns is a well-earned tribute, and definitely spells PROGRESS in the plastics industry.

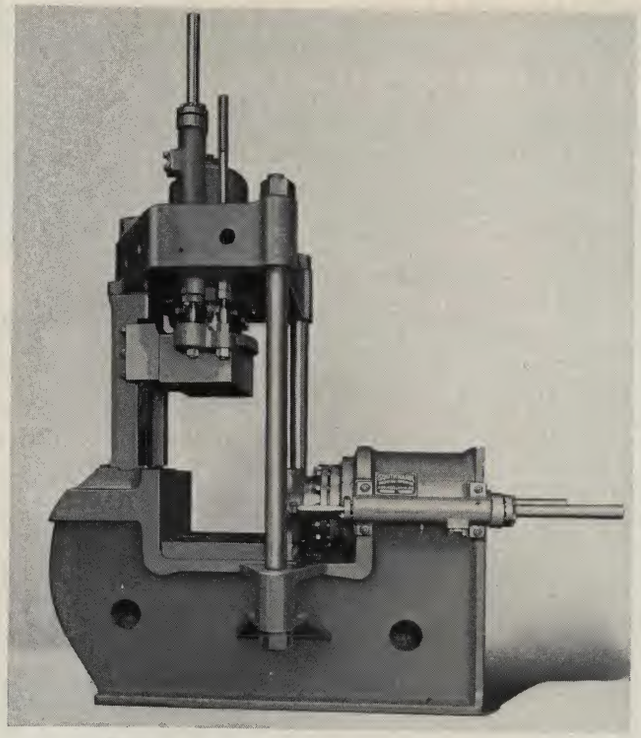
This year, as in previous years, Reed-Prentice equipment played a vital part in the molding of a large share of the winning entries. While the list of these winners is ample evidence of Reed-Prentice's leadership, still more impressive is the list of profit-winners, produced on our machines the year 'round.

Why not investigate at once the Reed-Prentice features which will assure *you* consistent profit-winners?

REED-PRENTICE CORPORATION

WORCESTER, MASS., *Main Office and Works*

OVER 300 MACHINES IN SUCCESSFUL OPERATION



8—Baldwin-Southwark 200-ton angle press. Side ram action permits operating single and multiple cavity split molds

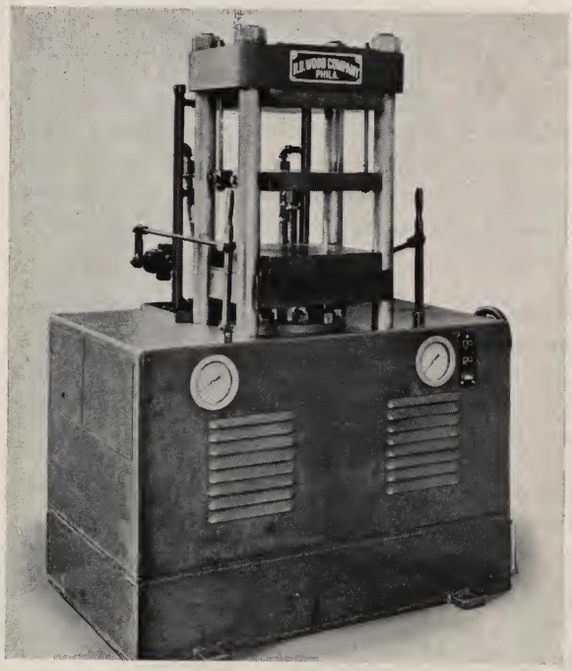
against suitable machined surfaces on the side plates. These are usually adjustable allowing takeup for wear, enabling the operator to keep the guiding of the moving platen accurate at all times. In order that there may be no binding or loosening of the guides when the press is heated up, it is customary to develop a certain angle of the guides so that the heat expansion will cause the gibs to slide along this surface instead of binding or opening up. The advantages of this type of guiding are quite obvious. On the older type of presses it is customary to use extra large dowel pins or guide pins in the molds in order that proper registration may take place. With the side-plate or gib guide type of press, it is possible to use smaller dowel pins and also relieve the wear on the pins themselves. On the older four rod type of press it is customary to use babbitt guides which require complete replacement when they become worn.

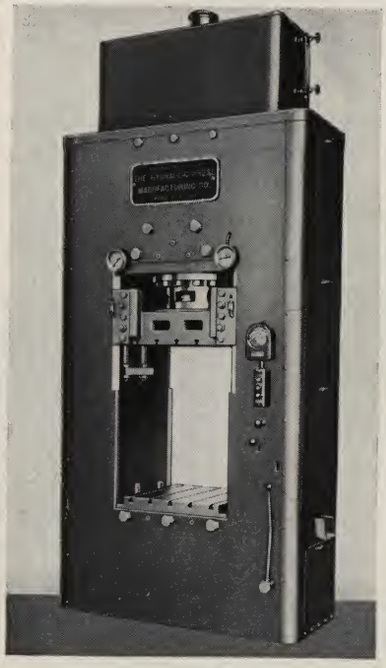
At first there was some criticism that the steel side plates shut off the accessibility of the dies on each side but this has been taken care of by cutting suitable openings or windows in the side plates. This still leaves sufficient tension area in the plates to take care of the load.

Another variation of the side-plate type is where the rolled steel plates are used front and back instead of on each side. These plates are cut out in the center and the cylinder and the top head mounted between the two plates and bear against the edge of the cut out opening. It is then possible to cover over the two plates with suitable sheet metal giving a complete streamlined appearance and this is especially adaptable where the press is self-contained with its own pumping unit which can be placed between the two plates.

Hydraulic pressure supply

All hydraulic plastic molding presses were originally operated from a central accumulator and pumping system as there were no modern rotary oil type of pumps available. The accumulator generally consisted of a weighted tank, that is, with ballast hanging on a ram, having the proper size to develop the correct pressure. This accumulator or reservoir was pumped up by means of a triplex or three-plunger pump and sometimes by means of a steam pump. This accumulator was designed to have sufficient capacity to take care of several presses opening





9—R. D. Wood Co. 50-ton steam platen press, equipped with northern radial piston pump. Ram diameter 6½ in. with 14 in. stroke. 10—Downward acting Hydraulic Press Mfg. Co. compression molding plate frame press. Mechanical upper knockouts are actuated by main ram return



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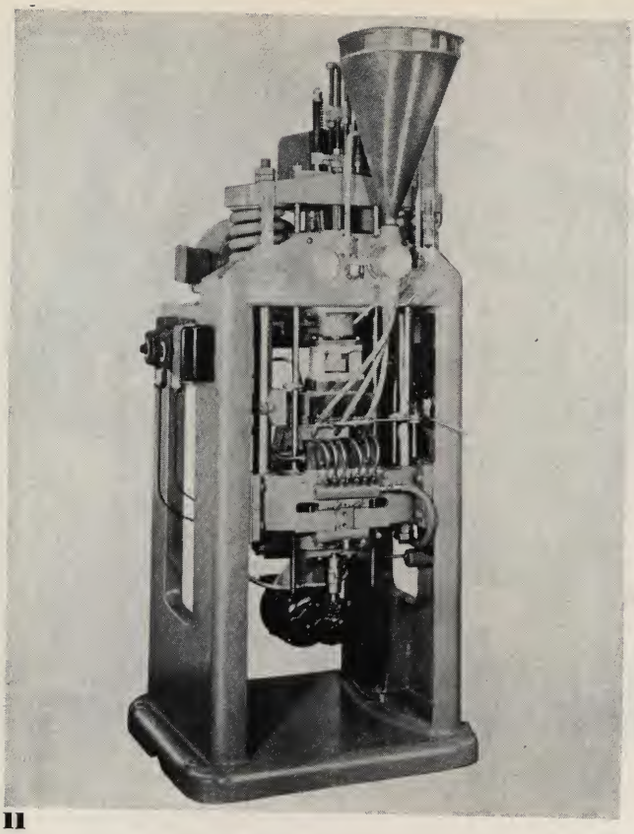
PHILLIPS RECESSED HEAD SCREWS...

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SPECIAL THREAD-CUTTING SCREWS • SCREWS WITH LOCK WASHERS

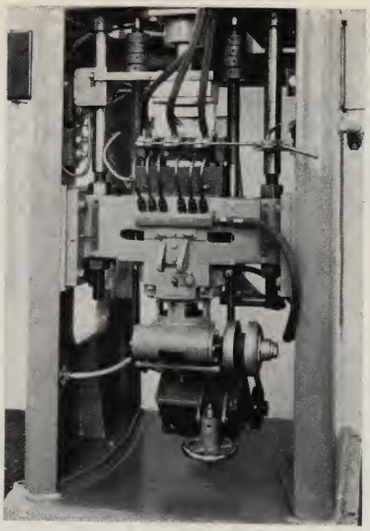
Speed Product Deliveries by Cutting Assembly Time

U. S. Patents on Product and Methods Nos. 2,046,343; 2,046,837; 2,046,839; 2,046,840; 2,082,085; 2,084,078; 2,084,079; 2,090,338. Other Domestic and Foreign Patents Allowed and Pending.

American Screw Co., Licensor, Providence, R.I.
Continental Screw Co., New Bedford, Mass.
Corbin Screw Corporation, New Britain, Conn.
The Lamson & Sessions Co., Cleveland, Ohio
National Screw & Mfg. Co., Cleveland, Ohio
Parker-Kalon Corporation, New York, N.Y.
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Scovill Manufacturing Co., Waterbury, Conn.
Shakeproof Lock Washer Co., Chicago, Ill.



11



12

11—Completely automatic molding machine built by F. J. Stokes Machine Co. Molding compound is measured and fed to mold, and molded parts are ejected automatically. 12—Close-up view of the mechanism of unscrewing device for this automatic molding machine—appropriate for handling such parts as bushings, bottle caps, ferrules and knobs

at the same time and the pump had a capacity to handle the total number of presses opening and closing within a definite period of time.

In some cases a two-pressure system is used, that is, a low pressure for rapidly closing the press and then a high pressure for the actual final pressure. Three thousand lbs. per sq. in. are generally used on the accumulator type of press, but this varies from time to time.

Self-contained presses

This is again a more recent development which has become more universal throughout the trade especially with those molders who are making parts for their own manufactured products. This type of press is unquestionably most desirable when only one or two units are required and it is a question of economics as to when the design should change from the self-contained type to the accumulator type.

The hydraulic press manufacturer has a number of pumps available for the operation of these presses. Some of these are of rotary-piston type where an eccentric action of a ring carrying the plungers generates the desired flow and pressure.

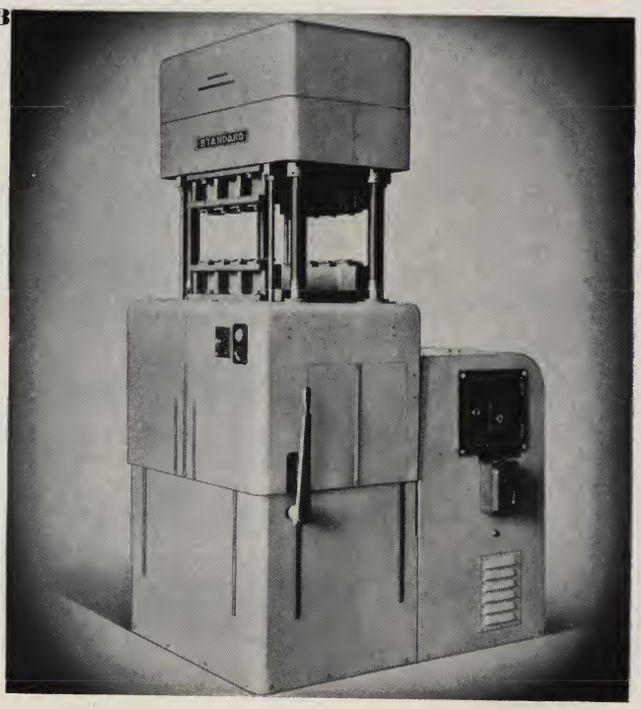
There is also the rotary-vane type of pump consisting of a series of vanes operating in an eccentric ring to develop the required pressure supplied. Both types have been used successfully by various manufacturers.

One of the advantages of the self-contained type is that individual presses may be run individually without having to run a complete accumulator system. This also avoids long hydraulic lines from the accumulator and pump to the presses with the accompanying high cost of maintenance for such equipment.

In some few cases presses have been equipped with a hand pump where it was not economical to install either a self-contained motor driven pump or connect up to an accumulator line. *(Please turn to next page)*

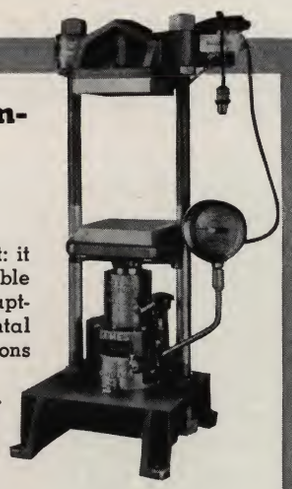
13—Standard Machine Co. semi-automatic toggle-type press. Construction permits the control of closing speed under final compression

13



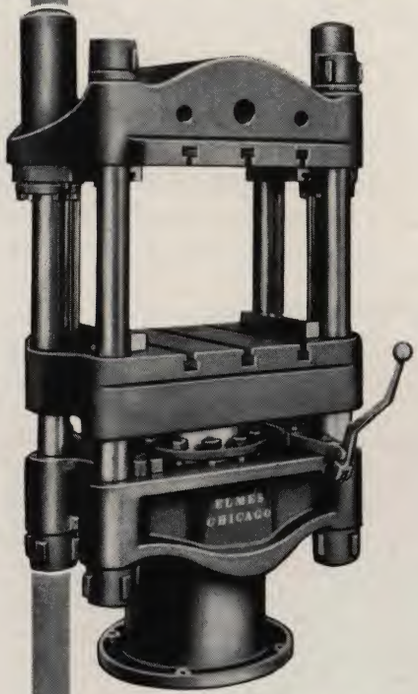
Elmes MAKES THE MODERN EQUIPMENT THAT *Molders of Modern Plastics* USE AND ENDORSE . . .

These Elmes Presses are giving superior performance in many plastic molding plants.



ELMES HYDRAULIC LABORATORY PRESS

This press is a precision instrument: it serves as an accurate and dependable basis for production plans and is adapted to a wide variety of experimental work. Available in pressures of 20 tons and over
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ELMES 4-COLUMN MOLDING PRESS

The industry has shown its approval of the flexibility of this self-contained molding press. Features are: variable high and low pressure pump; manual or fully-automatic control; top and bottom knockouts; moving platen accurately guided by extra long guides.



ELMES CABINET-TYPE PRECISION PRESS

Features of this semi-automatic, self-contained Elmes model are: top and bottom knockouts—high and low pressure pumps; adjustable pressure control; automatic time cycle; automatic breathing cycle; push button operation.

Improvements of product . . . lower costs . . . these are the factors which have made Elmes Presses the preferred equipment in up-to-the-minute molding plants. A wide range of Elmes equipment, to meet practically every special need is available for prompt delivery. Let Elmes know your requirements and get trustworthy recommendations.

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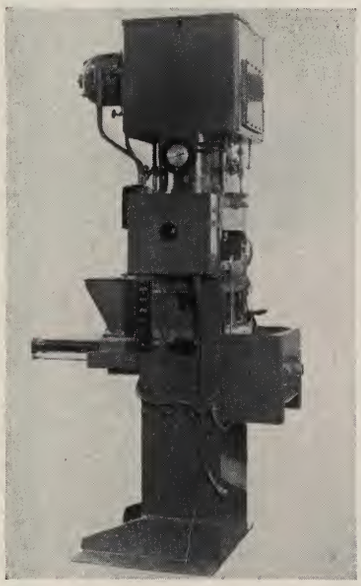
Miscellaneous types

In addition to the standard types noted above there are also several special types of presses one of which is the angle molding press. This was originally developed for molding angular pieces and the press has a vertical and also a horizontal ram. This type of press can also be used for recessed dies that cannot be split vertically alone. In other words, the die can be made of the three part type using the two rams to close the side and the top. This type has also been used for simplified injection molding, that is, by using the side ram to close the die and then mounting a plunger on the vertical ram to force the material into the mold.

Another special press for compression molding is the tilting-head type which was originally built so that the whole top head tilted back after the ram had dropped down, allowing the operator to get at the bottom and top molds more readily for unloading and cleaning. A still later development of the tilting-head type or rather of the tilting-platen type is where both the top and bottom platens move out the front, at the same time they are tipped giving still greater accessibility to the molds. These are also equipped with automatic stripping or ejecting devices.

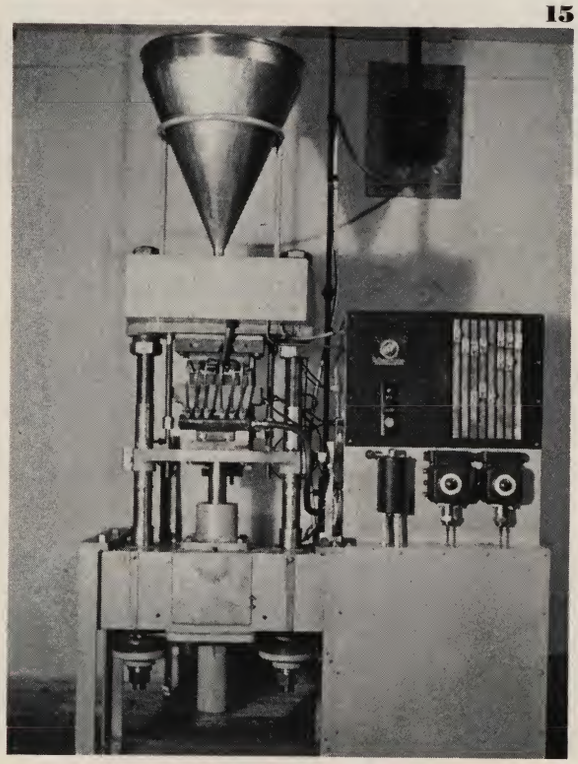
Another variation of the compression molding presses is the toggle type. Instead of a straight hydraulic ram pushing up against the bottom platen, there are interposed a set of toggles so that the ram itself can be operated under low pressure and through the toggles increase the force of the pressure against the platen. Another variation of the toggle press is where no hydraulic ram is used and the action is mechanical by means of an electric motor directly driving the movement of the toggle.

14



14—Automatic hydraulic press by Watson - Stillman Co. also adapted for manual operation. Has double acting hydraulic cylinder with prefill tank housing, prefill valve and pumping unit mounted on top of the press

15



Operation and controls

The simplest forms of control on accumulator operated presses are the hand operated valves which are generally of the screw stem type. The operator merely closes the exhaust line with the turn of one valve and opens the pressure line with the other, causing the press to close and build up to the required pressure. Similarly, where heating and cooling were needed the steam and cold water valves were manually operated.

With the introduction of the self-contained press it was possible to obtain not only quick and accurate control of the movement of the ram, but also the pressure as well. In other words, it is possible for the operator to set, by means of a certain valve, the desired pressure which is generally anywhere from the maximum down to practically zero to suit the particular piece or part being molded. This is of considerable advantage when small molds are being run in a large press as it eliminates the excess pressure which is apt to damage the mold. Also when delicate inserts are used, too much pressure is apt to either break or move them out of position.

One of the most important developments of recent years is the time cycle control of the operation. This can be used on either the accumulator operation or the self-contained type of press. On the accumulator operated press, diaphragm type of valves is used having a large air diaphragm at the top and the time cycle control is essentially a synchronous motor with a cam which operates small air valves. When the press is loaded, the time cycle control is started and the press is closed and held to a definite period of time and then opened. It is also possible to gas the mold or, in other words, release the pressure temporarily and then automatically come on again. Where heating and cooling are required in the cycle, it is possible to operate the steam and cold water valves the same way and from the same timer. In the

15—Self contained automatic press with adjustable cycle by Cropp Engineering Div., Warren Lamp Co. Designed primarily for molding thermosetting materials

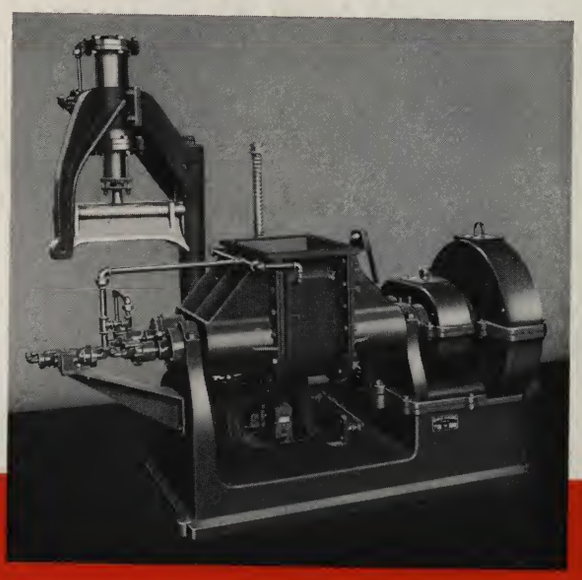
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. . FOR THE PLASTICS INDUSTRIES

The most complete line of mixers ever developed—Mixers for every kind of service—Laboratory, Pilot Plant or Production. Mixing, Kneading, Dispersing—no matter what your Plastic Product, you can secure reliable production at a minimum of cost with B-P Equipment. In a B-P machine, made of any suitable alloy, you get correct engineering design and construction (if need be, specifically for your own product), and high efficiency operation with low upkeep and remarkably long life.

Consult with us. We can help you solve that mixing problem—no matter how difficult.



(Above) Heavy Duty Dispersion Mixer for compounding and incorporating pigments, fillers, plasticizers, etc. into heavy plastic masses. Built in capacities from ½ gallon to 150 gallons.

(Right) Newly developed Heavy Duty Vacuum Mixer. This machine, designed with but one stuffing box, operates under vacuum for removal of solvents and turns out a uniform batch free from metallic contamination and discoloration. All mixer parts coming in contact with the batch and vapors are protected by corrosion-resistant metals.



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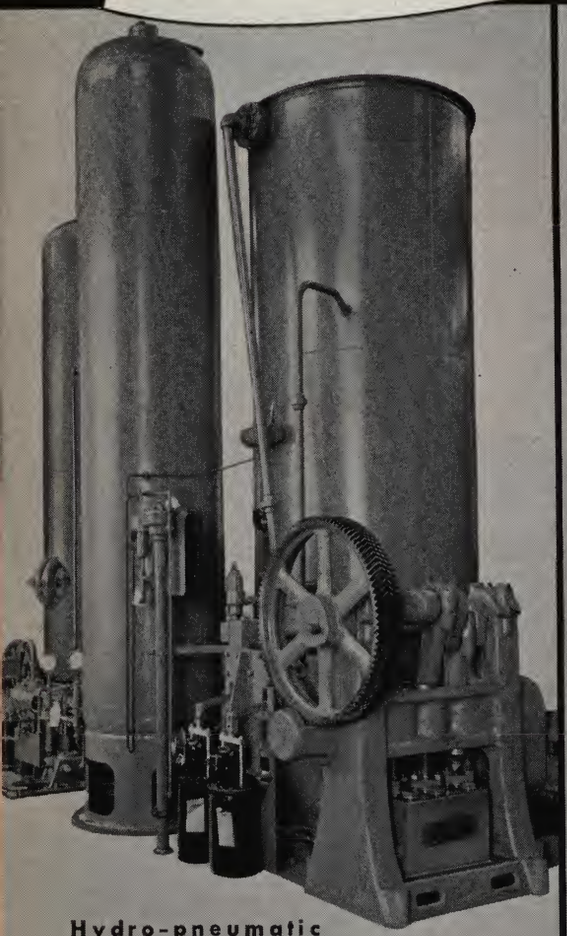
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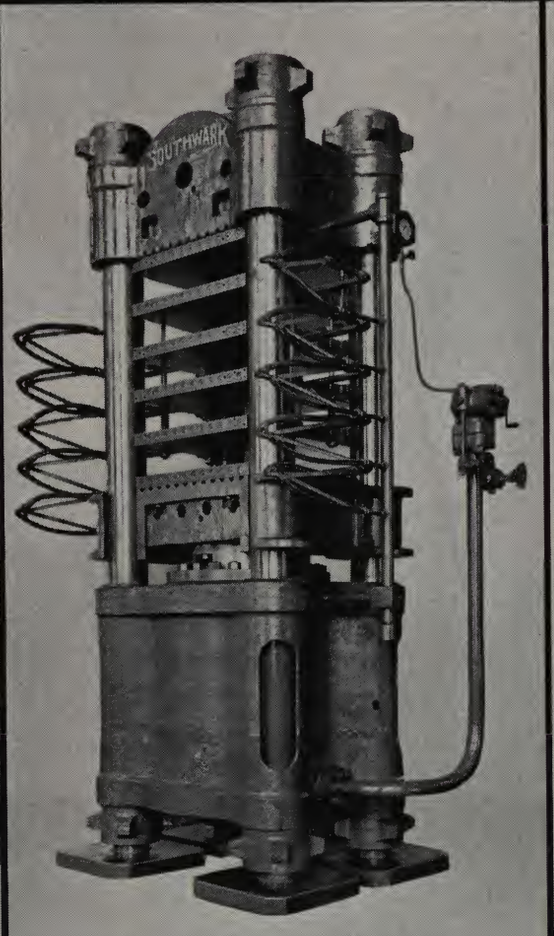
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SOUTHWARK HYDRAULIC PRESSES



Hydro-pneumatic accumulator systems



Southwark steam platen presses



Semi-automatic molding presses

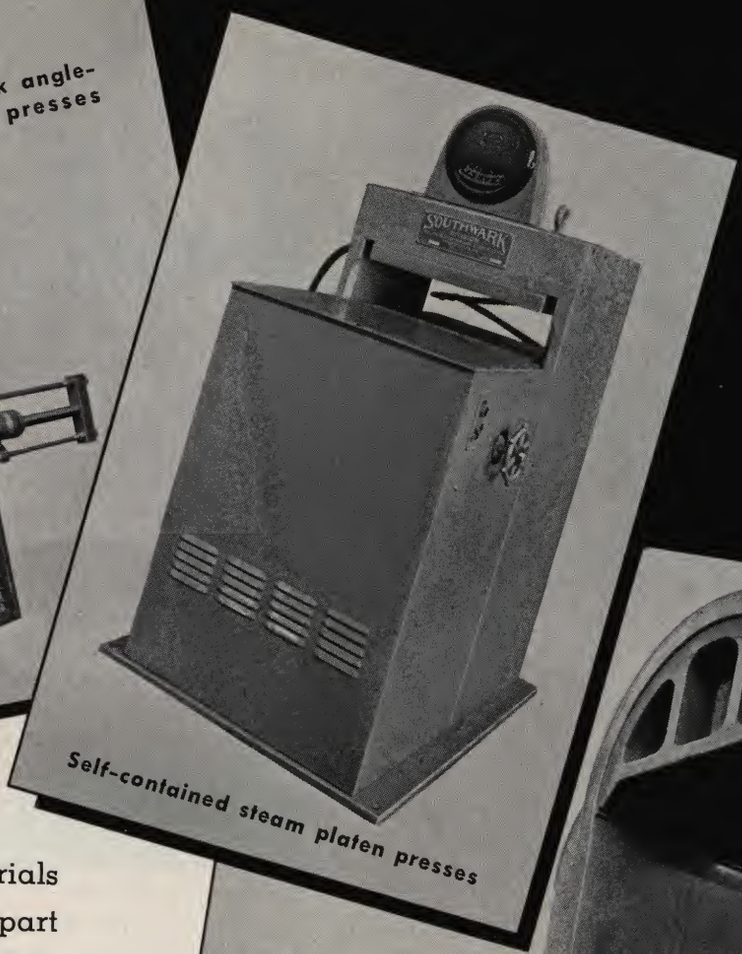
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Southwark angle-molding presses



Self-contained steam platen presses



Southwark die-hobbing presses

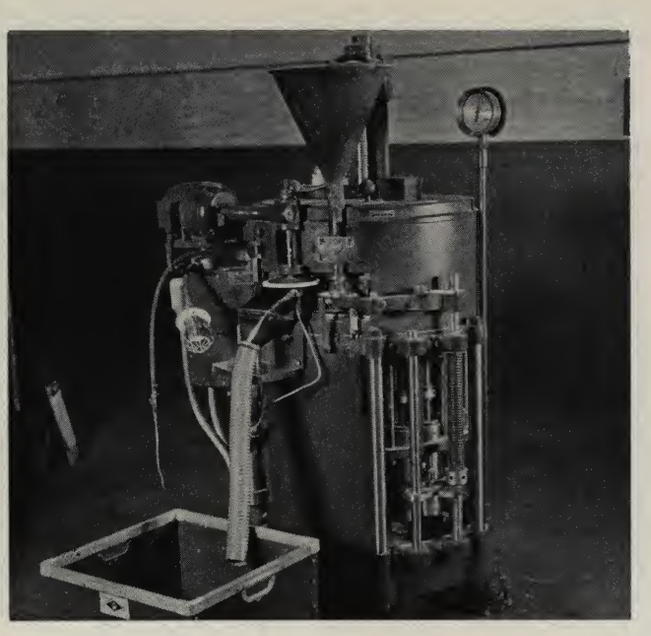
Sound design, good materials and honest workmanship are part of every Southwark press. Southwark's years of press building experience are paying real dividends to the leaders in the plastics industry.

Southwark builds a comprehensive line of modern plastics presses. Whatever your molding problem, consult with Southwark engineers. They can help you do a better job—more economically.

Baldwin Southwark Division of The Baldwin Locomotive Works, Philadelphia; Pacific Coast Representative, The Pelton Water Wheel Company, San Francisco.

SOUTHWARK

LOCOMOTIVE WORKS PHILADELPHIA



16

16—Automatic rotary press incorporating compression principle, developed by Lauterbach and Owens-Illinois. Machine is suited to continuous production of small parts such as buttons and closures. 17—Self-contained hydraulic press with electrically heated platens, manufactured by Wm. R. Thropp & Sons Co. 18—Side-plate construction tilting platen press by Lake Erie Engineering Corp. which allows ready accessibility to molds

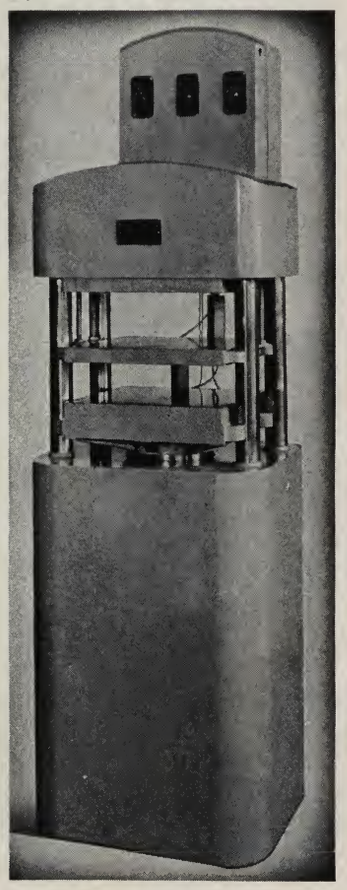
self-contained presses, the time cycle control is generally electric, that is, electrical solenoids are operated on the pressure valve although in some cases a similar type of synchronous motor with an air operated valve timer is used in conjunction with an air cylinder on the hydraulic control valves.

With this type of time cycle control, it is possible to duplicate the curing period exactly, eliminating all of the personal elements, insuring absolute uniformity of finished material, providing all of the other conditions are constant. With these time cycle controls it is possible to vary the cycle from one set of molds to another very easily.

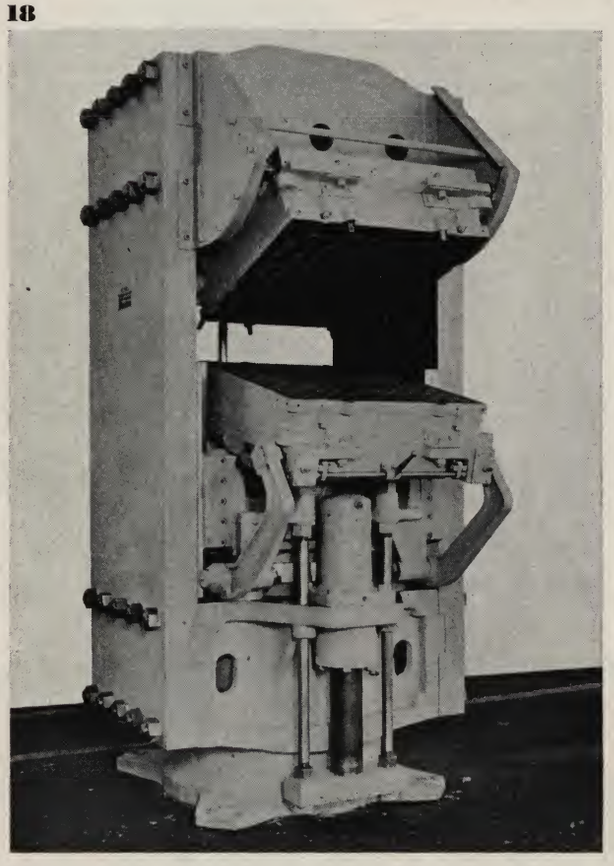
This time cycle control has been used principally with the larger manufacturers but it is expected that these will be introduced to a greater extent with the custom molders in order to avoid loss due to parts being over- or under-cured, causing scrap.

With self contained and automatic types of presses coming into more extensive use and with more and more specifications being written around production pieces the necessity for control has become increasingly important. The various types of presses require different devices for this purpose. Electric meters are coming into extensive use, electric operating switches are being more widely used and cycling units of various constructions are being adopted. The trend is continually toward more absolute non-varying molding that is once the conditions are established. Auxiliary equipment is contributing to that end.

17



18



DESIGNED FOR Plastics!

These two screws, specially developed for Plastic applications, reduce costs... assure tighter, stronger fastenings!



SHAKEPROOF *Thread-Cutting Screws*



TYPE 2—Double Slot

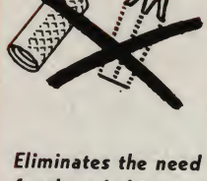


TYPE 9—Multi-Flute

These screws actually cut their own standard machine screw threads in either molded or laminated plastic materials and can be driven into fragile sections without danger of fracturing. Because they remain in the threads they have cut themselves, a snug, tight fit, which results in a stronger fastening, is always certain. Their use eliminates the need for threaded inserts or separate tapping, which definitely reduces assembly costs.

WRITE FOR TESTING SAMPLES!

Convince yourself regarding the cost-lowering and efficiency-increasing advantages of Shakeproof Thread-Cutting Screws. Write today for free samples. Test them in your own shop on your own applications. In your request for samples, be sure to state type desired—write us now!



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SEMS Fastener Units . . . Lock Washers . . . Locking and Plain Terminals

Thread-Cutting Screws . . . Locking Screws . . . Spring Washers . . . Special Stampings

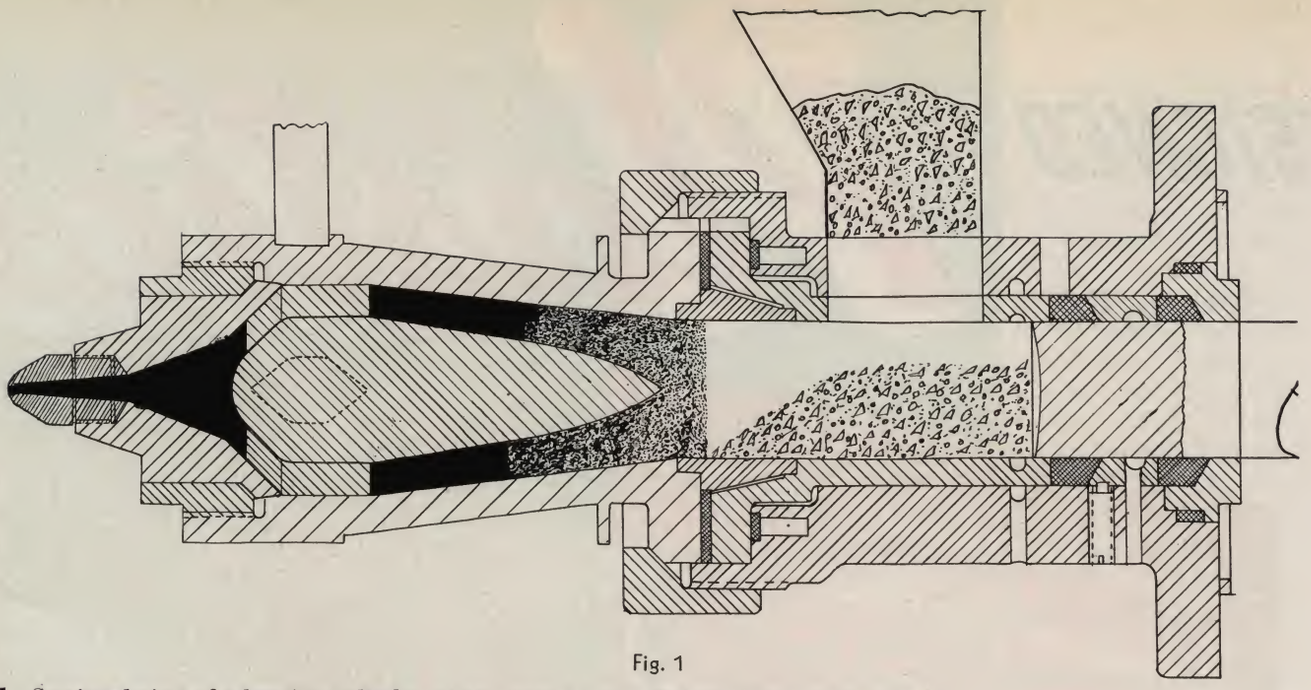


Fig. 1

1—Sectional view of a heating cylinder on the Isoma, an early completely mechanized injection machine. The plasticizing capacity of these earlier units was limited to grams

Injection presses

DURING the short period of about five or six years injection molding in the U.S.A. has advanced from a stage where 1 oz. castings were considered an achievement, to the position where 12 oz. castings are accepted as a fact. This rapid development is truly a tribute to the American spirit of cooperation. It is only through the close cooperation of the material manufacturer, the machine builder, the mold designer, and the molder that this remarkable progress could be achieved. Today it is possible for the American molder engaged in the injection molding of thermoplastic materials to secure machines which can successfully inject castings up to 12 oz. in weight with a single-injection cylinder. He can also secure larger machines which can produce 32 oz. castings by use of a series of injection cylinders.

Single cylinder injection presses

In this section we review briefly the development of the single cylinder injection presses and will attempt to point out some of the factors which influenced its development.

A brief survey of the patents issued on the subject of extrusion discloses that on November 19, 1872, a patent* was issued to J. Smith Hyatt and John W. Hyatt covering a machine for the extrusion of celluloid. This machine embodied in its heating cylinder many of the same principles that are employed in the design of the heating cylinders on our present-day machines. As shown on the above-mentioned patent the heating cylinder used in the Hyatt machine cylinder contained a central core, the purpose of which was to reduce the thickness of the section of the material and thereby secure thorough plasticizing of the material as it progressed through the cylinder. The central core as well as the outside shell contained many pegs which protruded into the path of the material and gave added surface for the material to contact and absorb heat in its passage through the heating cylinder of the machine.

Due to the ever-present danger of explosions when cellulose nitrate is subjected to heat and pressure, the development of this machine for purposes other than the extrusion of rods or tubes was greatly hampered.

As time progressed, a new material, cellulose acetate, was offered as a molding material. This material was thermoplastic and non-explosive and was readily adapted to the process of injection molding. With the development of cellulose acetate molding powder and various other thermoplastic materials, interest in the injection method of molding gained much momentum.

Patent No. 2,057,945, issued to Hans Gastrow on December 10, 1932, covered the heating cylinder used on the Isoma injection molding machine. The sketch in Fig. 1 shows this cylinder as described in the patent.

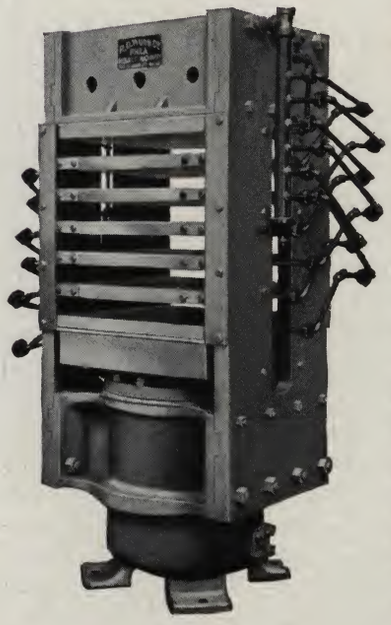
It is to be noted that this cylinder is streamlined throughout and reduces greatly the friction developed

* U. S. Patent No. 133,229



R. D. WOOD PRESSES

are designed and built for high production, easy operation, low maintenance and long life. The line of standard Wood hydraulic presses includes units of practically every type and size, and special presses will be built to meet unusual requirements. Wood engineers will be pleased to consult with you on your press problems.

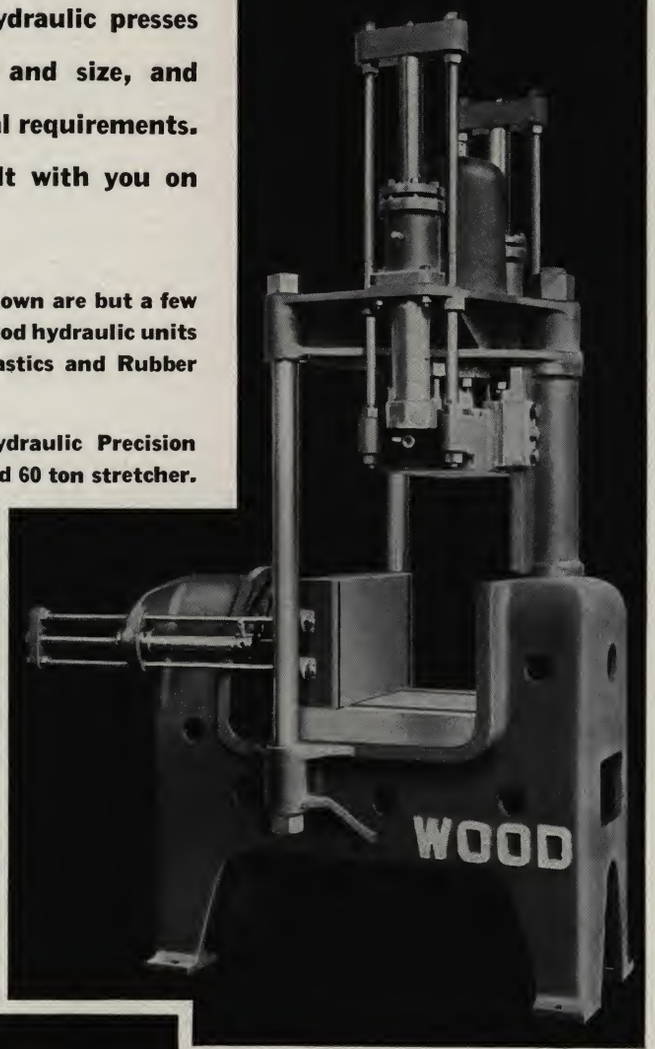


The three presses here shown are but a few of the many standard Wood hydraulic units that are used in the Plastics and Rubber Industries.

Above is a 3180 ton Hydraulic Precision Belt Press with clamp and 60 ton stretcher. Steam plates 66″ x 30′-0″ have polished working surfaces.

At the right is a 63 ton Angle Molding Press having an 8″ diameter x 16″ stroke vertical ram and an 8″ diameter x 10″ stroke horizontal ram.

At the left is a 314 ton steam Platen Press with a 20″ ram and 18″ stroke. The six platens are each 30″ x 30″ x 2″.



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R.D.Wood Co.

PHILADELPHIA, PA.

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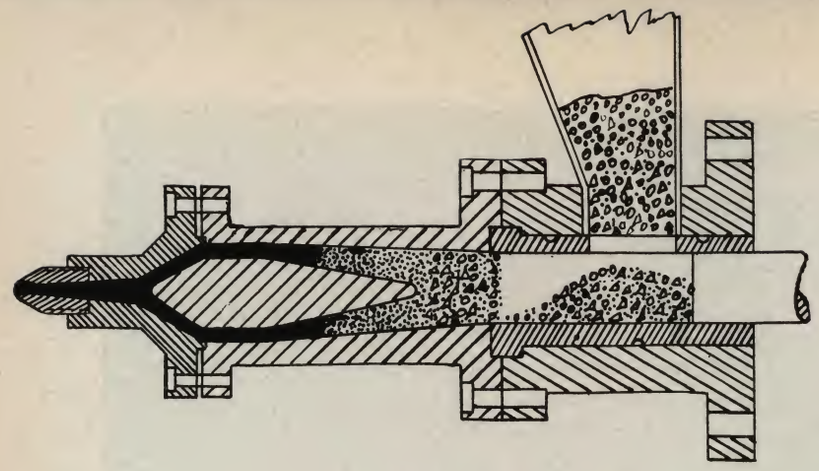


Fig. 2

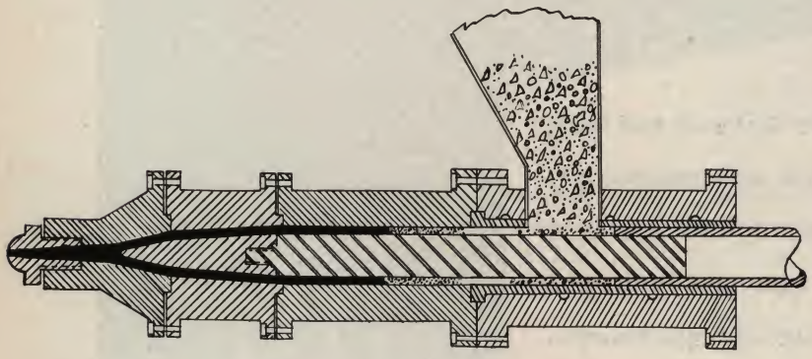


Fig. 3

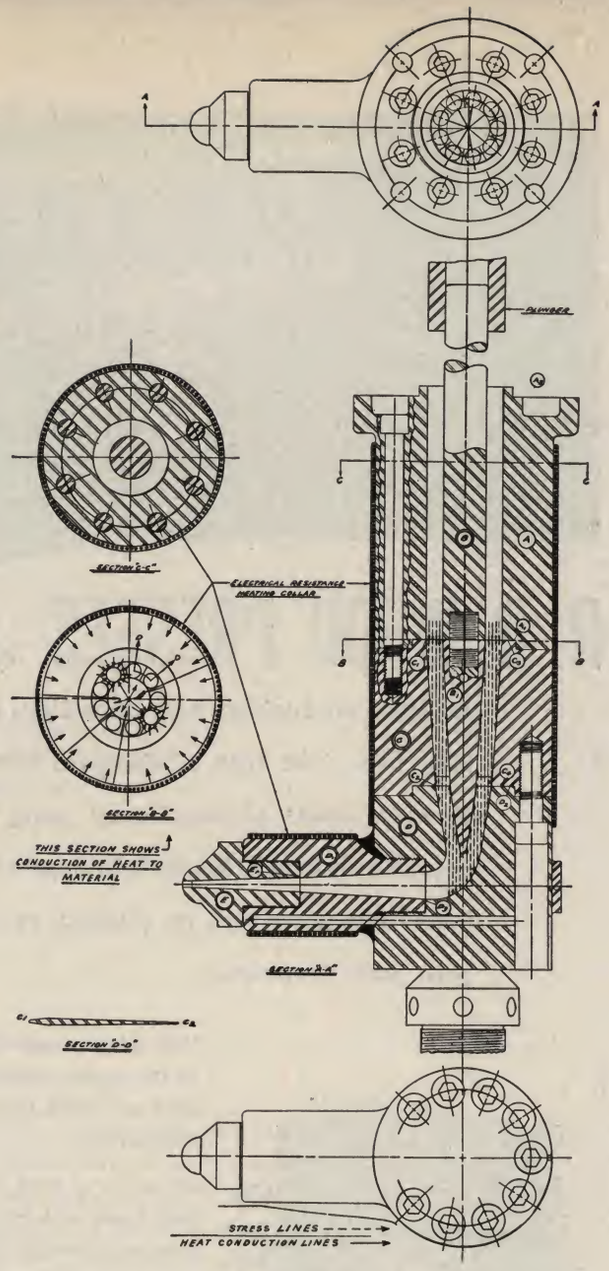


Fig. 4

2—Piston admits powder charge directly into chamber after each stroke. Material is confined to area of injection ram travel. 3—Injection heating unit designed to spread material within the chamber. Heat is distributed evenly. 4—Vertically arranged injection unit which reduces the overall floor space occupied by the machine

between cylinder and the material as it is forced through it. This design did much to eliminate burning and discoloration which results if material is forced through a cylinder with the old-type construction. By streamlining the cylinder the danger of having material collect inside of the cylinder and be subjected to the heat of the heating cylinder for too great a length of time is eliminated because no pockets are created where the material can lodge.

With the introduction of this machine on the American market the interest in the injection method of producing castings from thermoplastic materials was soon aroused. The possibilities of this process were recognized and it was only a short time until the importance of injection molding began to assert itself. Its practicability as a method of production was quickly acknowledged and presently demands for larger machines were heard.

One of the greatest problems involved in this development of larger machines was the design of a suitable heating cylinder. Experience proves that it is absolutely necessary for the heating cylinder to be designed so that the wall thickness of the material to be heated is kept sufficiently thin so that the heat will penetrate the material rapidly, and insure plasticization. On the other hand it must not be so thin that the internal friction set up in the cylinder between the walls of the cylinder and the material will greatly reduce the effective pressure when the material is forced into the mold.

It is evident that in the last cylinder discussed above, one dominant problem asserts itself. The material enters the cylinder in a granular form. As it is forced forward by the injection plunger it must be broken up over the end of the spreader and forced into a thin section to permit plasticization. This breaking up requires considerable pressure, and as larger capacity machines became necessary the problem became more involved.

It was discovered that the type of construction shown in Fig. 1 was successful for machines where the capacity of a single injection was $1\frac{1}{2}$ oz. or less. If larger capacities were attempted the pressure exerted against the tail end of the spreader would loosen the joint between the spreader and the outside shell of the cylinder, thus permitting material to get into the joint and burn.

In Fig. 2, another development in the design of heating cylinders is shown. In this cylinder the central core is made integral with the outside shell of the cylinder, thus eliminating the joint between *(Please turn to page 327)*

STOKES MOLDING EQUIPMENT

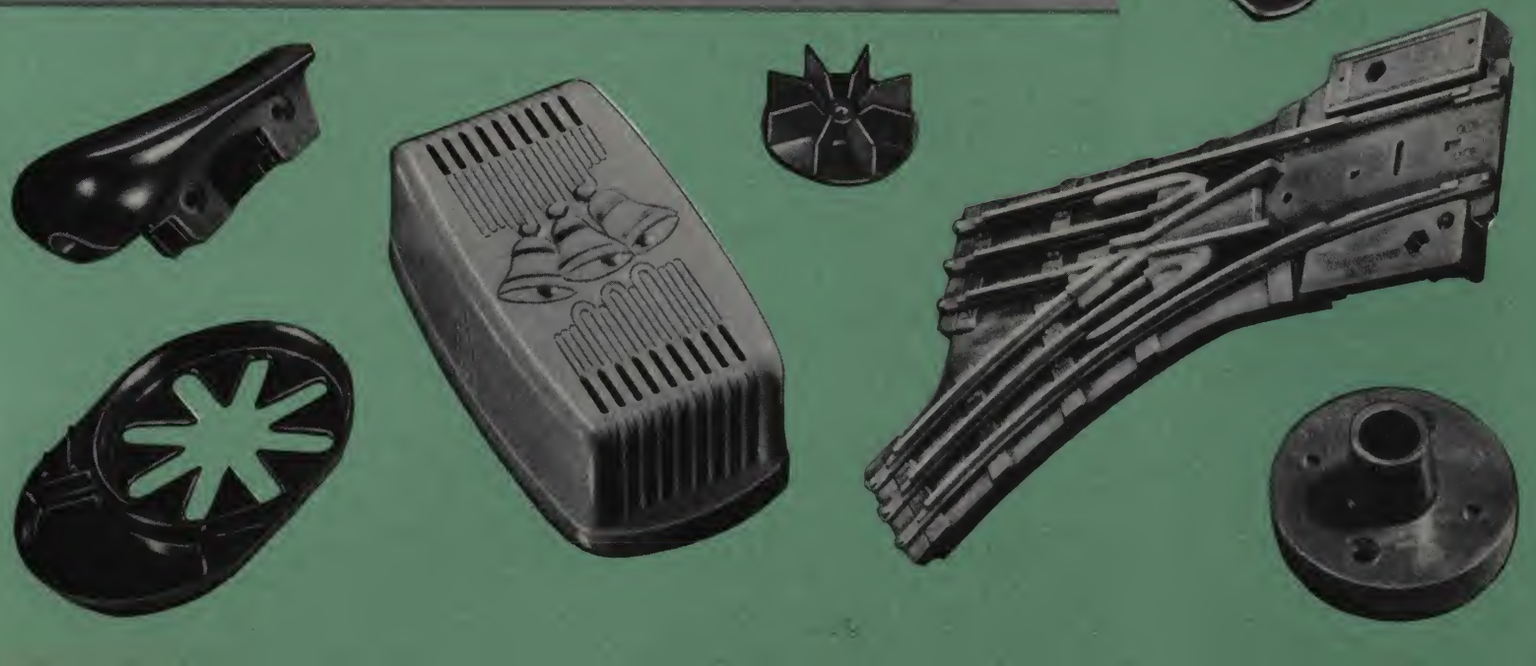
To the production of molded plastics Stokes equipment brings . . .

- Modern, Automatic Manufacturing Methods and Economies.
- Marked Improvements in Product Quality.
- Substantial Savings in Labor, Material, Finishing and Other Costs.

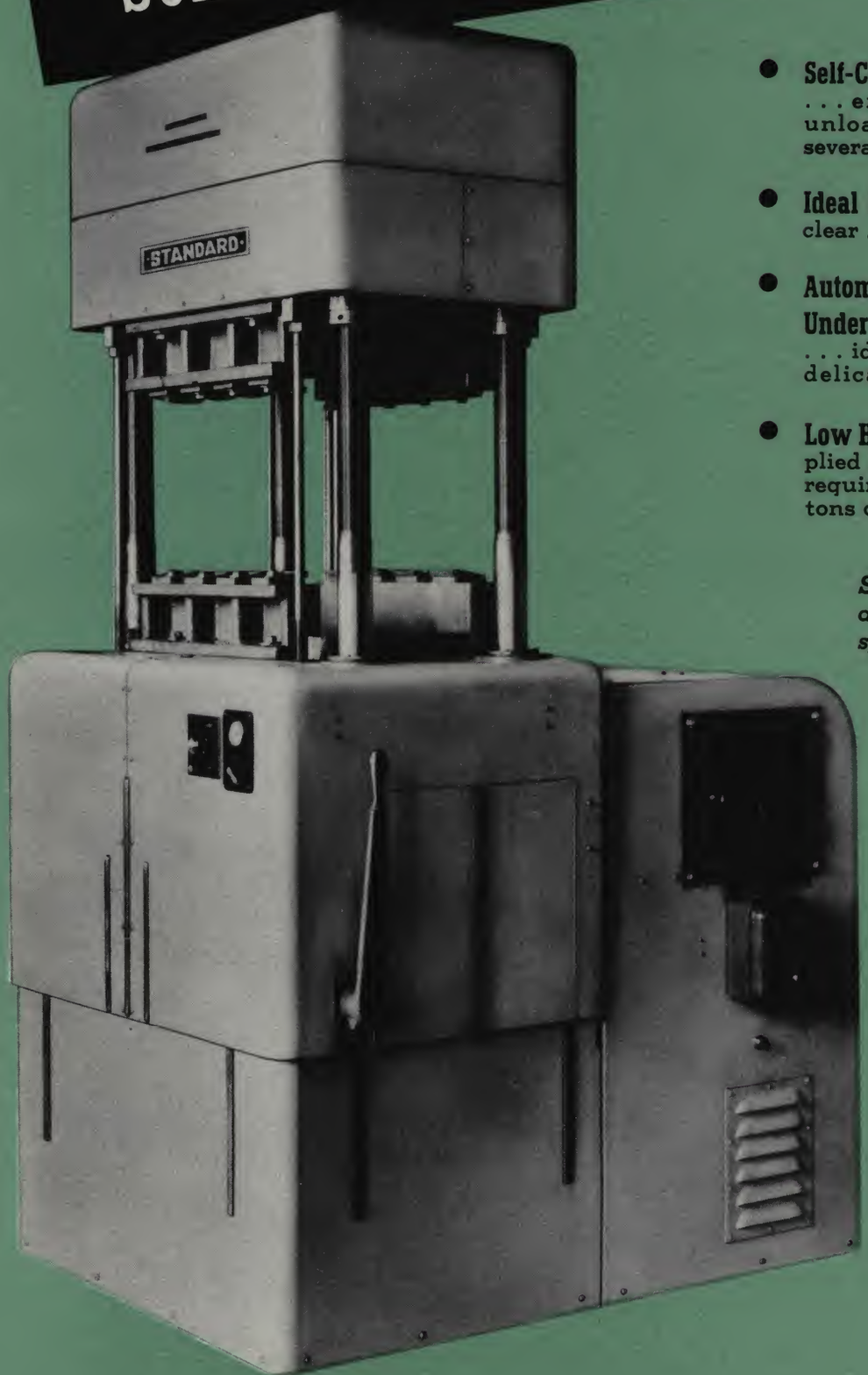
We have specialized in the design and manufacture of automatic machinery for more than 45 years . . . have served the plastics industry since its start. There is hardly a custom molding plant in the country in which Stokes equipment is not used.

To make better moldings, faster, cheaper . . . we offer the Stokes Molding Equipment shown on the following pages.





STOKES "STANDARD" Semi-Automatic Molding Presses



- **Self-Contained Units.** Automatic . . . except only loading and unloading. One operator runs several presses.
- **Ideal Molding Action.** Fast in the clear . . . slow in the mold.
- **Automatically Timed "Slow-Closing Under Compression."** A new feature . . . ideal for precision molding, delicate insert work, etc.
- **Low Hydraulic Pressures** . . . multiplied by toggle action. Low power requirements. Six sizes, 20 to 300-tons capacity.

See last page of this advertisement for specifications.



Write for catalog.

"Standard" Presses are Preferred Equipment

There's a growing appreciation of the advantages of these Semi-Automatic Presses. Hundreds are in use. During the past two years many new plants have installed these presses exclusively. Recent improvements in automatic controls greatly increase their flexibility and adaptability. With the new "Slow-Close Under Compression" feature, for example, the final closing speed is automatically slowed down, may be timed for from one second to 20 minutes, as required by the mold or work.

•

Output Increased . . . More Heats Per Hour

Automatic cycle control saves every second. There's no loss of time through overcure. The curing cycle is shortened by accurately controlled "breathing." Man-hour output is increased. Operators can tend several presses. Skilled operators are not required. Human error is eliminated . . . there are fewer rejects.

•

Mold Wear and Tear Reduced

"Standard's" exclusive toggle action and automatically timed "Slow-Closing" eliminate the danger of forcing molding material before it is ready to plasticize and flow. The toggles raise and lower the platen from its four corners and eliminate "cocking." Pressure, once adjusted, cannot exceed the maximum for the mold. Mold maintenance is negligible.

•

Uniform Moldings Produced . . . Material Saved

These presses are ideal equipment for precision molding, delicate insert work, button manufacture, moldings with thick and thin sections or having pins or projections which are liable to damage . . . as well as for general molding work.

"Slow-Closing" makes it possible to load cavities with a minimum of material. In certain cases, with flash type molds, material savings as high as 20% have been obtained.

•

Power Saved . . . Maintenance Saved

Operating (power) cost of "Standard" Presses is low. For a 150-ton press, for example, a 3 h.p. motor only is required. In a metered test current cost for operating one of these presses 24 hours was only 48 cents (at 1.4c k.w.h.).

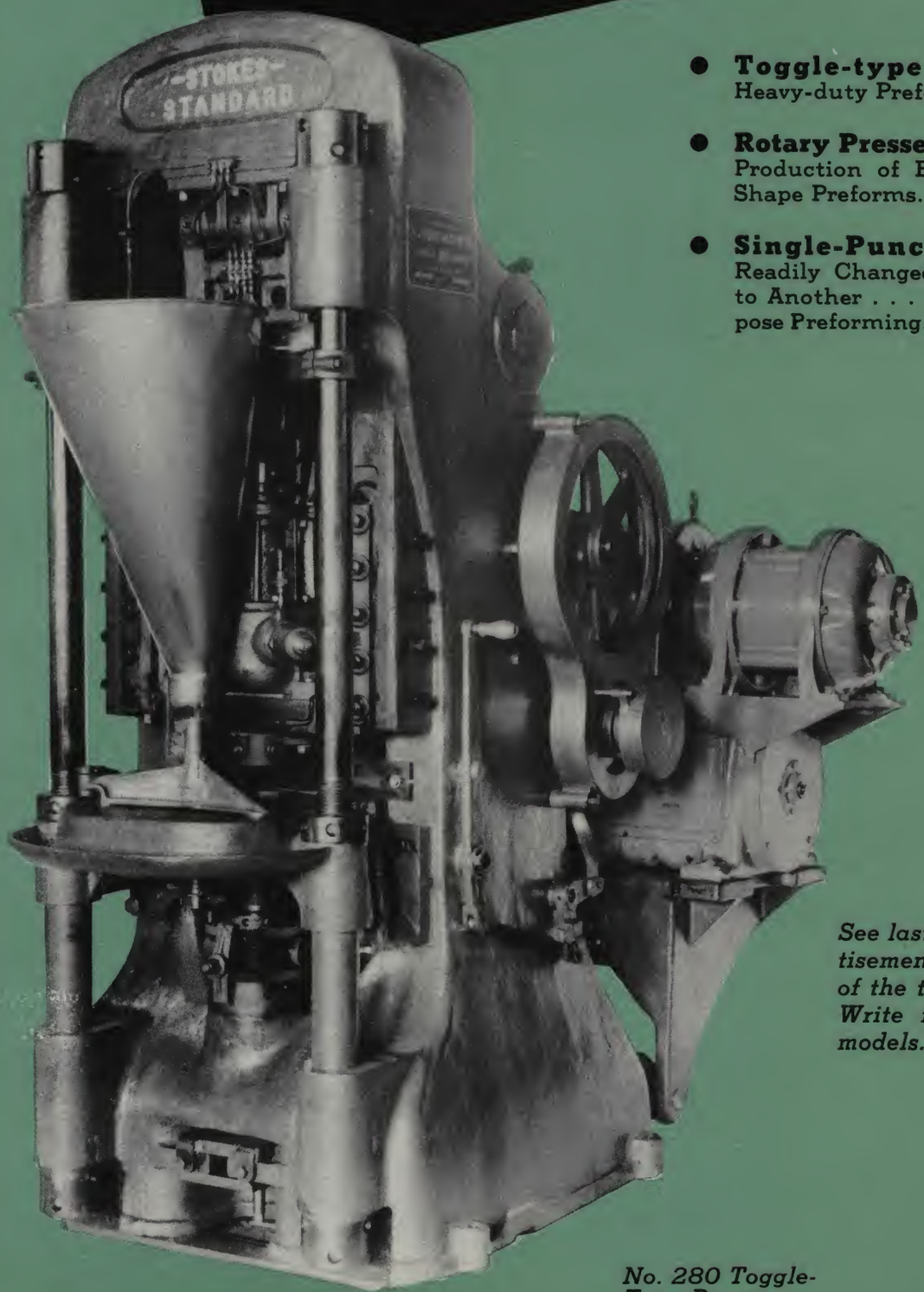
•

Another advantage . . . hydraulic pressures are low. Low pressure piping and simple valves and fittings are used. There are no hydraulic packings. Leaks are minimized. Press maintenance is negligible.



STOKES Automatic Preforming Presses

- **Toggle-type Presses** for Heavy-duty Preforming.
- **Rotary Presses** for High Speed Production of Ball or Standard Shape Preforms.
- **Single-Punch Presses** . . . Readily Changed from One Job to Another . . . for General Purpose Preforming.





No. 280 Toggle-Type Press

See last page of this advertisement for specifications of the three presses shown. Write for details of other models.



Hundreds of these Presses in Use

Stokes Preform Presses are automatic machines for compressing molding powders into tablets or pills of uniform weight, density and shape, preliminary to molding. They are available in types and capacities to meet every preforming requirement . . . fourteen standard stock models, to apply pressures up to 80 tons . . . also special presses of 200 and 300 tons capacity for special applications.

•

They are all simple, practical machines, built for the hard, continuous service to which such equipment is subjected in a molding plant and fully protected against overloads, jamming and damage.

•

Construction is exceptionally rugged. Frames are of semi-steel, combining the rigidity of castings with the strength of steel plate. Gears are well guarded. Bearings are large, bronze bushed. Simple adjustments to control pressure, density, weight and thickness may be made while machines are running.

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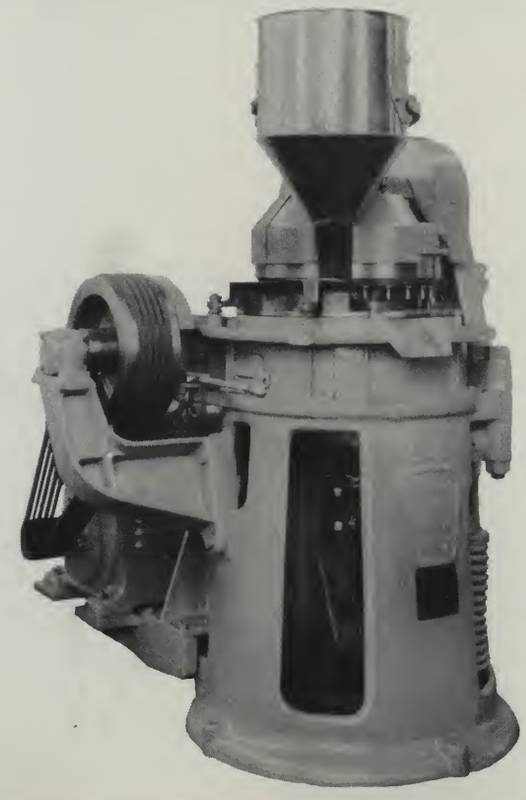
Variable speed drives assure maximum production on preforms of various size and with different type materials. Core-rod type punches and dies may be used . . . to make perforated preforms. Presses are quickly changed over from one job to another.

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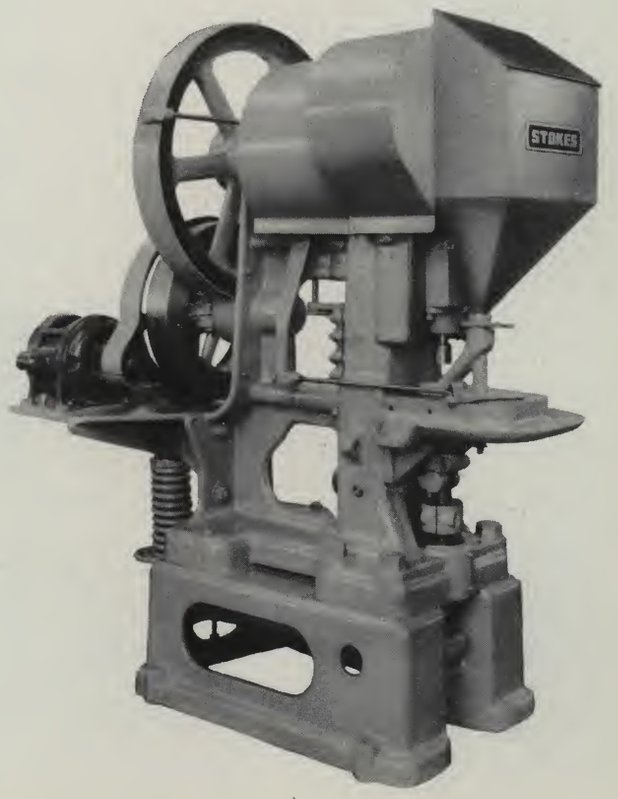
For Large Preforms, up to 4-in. diameter, use the No. 280 Toggle-type Press, applying pressures up to 80 tons. Strokes, 40 or 50 per minute.

For Large Output use a Rotary-type Press such as DDS-2. This machine makes standard shapes or balls up to $1\frac{3}{16}$-in. diameter at 300 to 350 per minute. Eight stock models of this type press. Production rates up to 1000 per minute.

For General Purpose Preforming we offer versatile Single-punch Presses, readily changed from one job to another. Four stock models. The "R" machine shown below has 2-in. die fill, makes preforms up to $2\frac{1}{2}$-in. diameter at 40 to 50 per minute.



No. DDS-2 Rotary Press



No. "R" Single-Punch Press

SPECIFICATIONS

STOKES COMPLETELY AUTOMATIC MOLDING MACHINES

Foreign and Domestic Patents Applied For

No. 200-A

STANDARD MODEL

Capacity.....10 tons
Stroke, up to.....4¼ in.
Maximum Piece Size:
Height, up to.....1½ in.
Length, up to.....6 in.
Projected area, up to...10 sq. in.
Diameter, up to.....3¼ in.
Power Required.....3 h.p.
Floor Space.....36 in. x 40 in.
Height.....6 ft. 6 in.
Net Weight.....1950 lbs.
Gross Weight.....2250 lbs.
Boxed for Export.....100 cu. ft.

No. 200-D

HEAVY DUTY MODEL

Same as No. 200-A with the following exceptions:
Capacity.....15 tons
Maximum Piece Size:
Projected area, up to...15 sq. in.
Diameter, up to.....4½ in.
Power Required.....5 h.p.
Net Weight.....2100 lbs.
Gross Weight.....2300 lbs.
Boxed for Export.....110 cu. ft.

No. 202

HEAVY DUTY LONG STROKE MODEL

Capacity.....15 tons
Stroke, up to.....10 in.
Maximum Piece Size:
Height, up to.....4 in.
Length, up to.....6 in.
Projected area, up to...15 sq. in.
Diameter, up to.....4½ in.
Power Required.....5 h.p.
Floor Space.....42 in. x 40 in.
Height.....7 ft. 7 in.
Net Weight.....2500 lbs.
Gross Weight.....2800 lbs.
Boxed for Export.....125 cu. ft.

"STANDARD" SEMI-AUTOMATIC MOLDING PRESSES

Maximum press capacity (tons)	*20	50	100	150	200	300
Maximum hydraulic pressure (lbs. per sq. in.)	900	875	550	800	1000	1000
Maximum mold or die area (L. to R., F. to B.)	12″x7″	20″x10″	24″x16″	24″x18″	26″x22″	36″x24″
Maximum platen travel or stroke	5½″	7″	6″ (8″)	6″ (8″)	8″	10″
Motor (1200 r.p.m.)—(h.p.)	2	2	3	3	5	5
Overall height	70″	76″	97″	97″	97″	117½″
Shipping weight complete (pounds)	1500	3400	7500	8000	12,000	19,000

*Special model of this press is available; air-operated (125 lbs.) without motor or pump.

STOKES PREFORMING PRESSES

No. 280 Toggle Press

Pressure.....80 tons
Strokes per minute Up to 50
Size of Preforms ..Up to 4-in. dia.
Max. Depth of Fill .2 in.
Dia. Core-Rod Hole 1½ in.
Height.....94 in.
Height to top of Die Table.....42 in.
Power Required ..7½ to 10 h.p.
Floor Space.....51 in. wide x 86 in. front to back
Weight.....12,000 lb.
Gear Ratio.....10 to 1

No. DDS-2

Pressure.....12 to 14 tons
Preforms per min...300–350
Size of Preforms....$1\frac{3}{16}$″–dia.
Max. Depth of Fill..$2\frac{1}{16}$″
Height.....73″
Power Required...5 to 10 h.p.
Floor Space.....52″ x 61″
Net Weight.....5700 lb.
Gross Weight.....6400 lb.
Boxed.....160 cu. ft.

No. "R"

Pressure.....15 tons
Strokes per min....up to 50
Size of Preforms....up to 2½″
Max. Depth of Fill..2″
Height.....79½″
Power Required...5 h.p.
Floor Space.....66″ x 36″
Net Weight.....4300 lbs.
Gross Weight.....4550
Boxed.....131

In addition to the above there are eleven other stock models.

F. J. STOKES MACHINE COMPANY · 5935 Tabor Road Olney P.O. Philadelphia, Pa.

Representatives in New York, Chicago, Cincinnati, St. Louis, Cleveland, Detroit, Boston. Pacific Coast Rep.: L. H. Butcher Co., Inc.

12M—12—40

PRINTED IN U. S. A.

F.J.Stokes MOLDING EQUIPMENT FJS Est. 1895

(*Continued from page 318*) the central core and the shell of the heating cylinder. This removes the possibility of having material force itself into the joint and burn, causing discoloration of the material.

As cylinders of this third type were built in larger and larger capacities a point was reached where the pressure exerted in forcing the material over the end of the spreader caused a tremendous loss in pressure and materially reduced the effective pressure on the injected material.

In order to overcome this difficulty cylinders were constructed with the plunger moving over the spreader as shown in Fig. 3. With this design the material enters the cylinder around the spreader shaft and does not have to be broken up after it has been compressed.

Fig. 4 is a cross-sectional view of a vertical type of heating cylinder. It is to be noted that this type provides a means for scraping off the material which may tend to stick to either the inside or the outside of the plunger. Such scraping action is of vital importance in the use of polystyrene material. The vertical type of heating cylinder was developed in order to reduce to a minimum the stroke of the injection piston when forcing the material into the mold. It will be noted that in the vertical cylinder the granular material falls directly into the cylinder and on top of the material which was compressed by the previous injection stroke. Hence the minimum stroke is required to force the material into the mold. Cylinders of this latter type have been successfully used on single-cylinder injection presses for the production of castings as large as twelve ounces.

Since the design of the cylinder for any injection molding machine is directly dependent upon the characteristics of the molding material to be used, it is difficult to determine just what the limits for the single cylinder press will eventually be. Improvements in material continually tend to increase the possibilities for the construction of single-cylinder presses of larger capacities.

Modern production with its ever-increasing demand for machines that are simple and dependable in their setup and operation, gives a definite position to single-injection cylinder presses in the injection molding industry.

The features of the single-cylinder press are as follows:

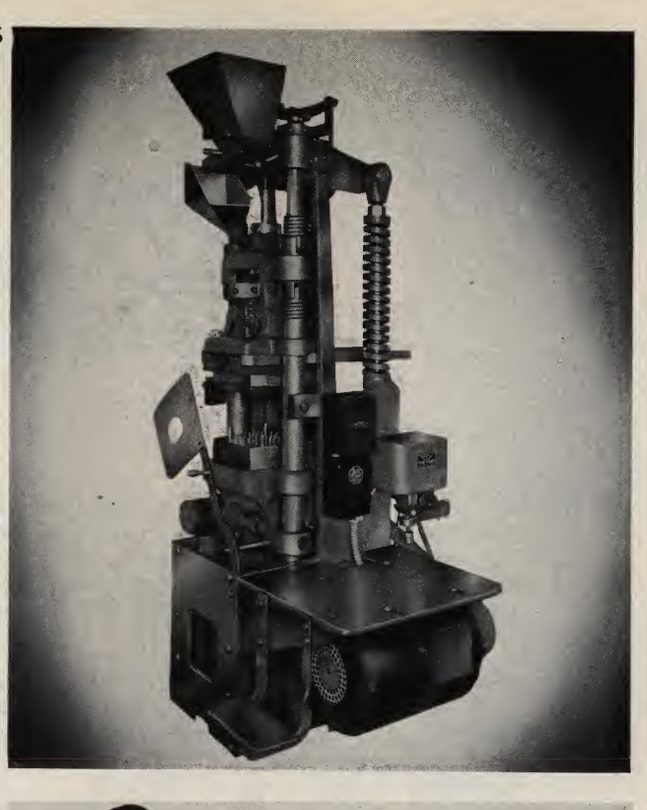
1—It is possible to make large castings with a single sprue thus reducing finishing costs and eliminating the weld line which is bound to occur if material enters the mold from more than one source.

2—The control for the single-cylinder press is very simple.

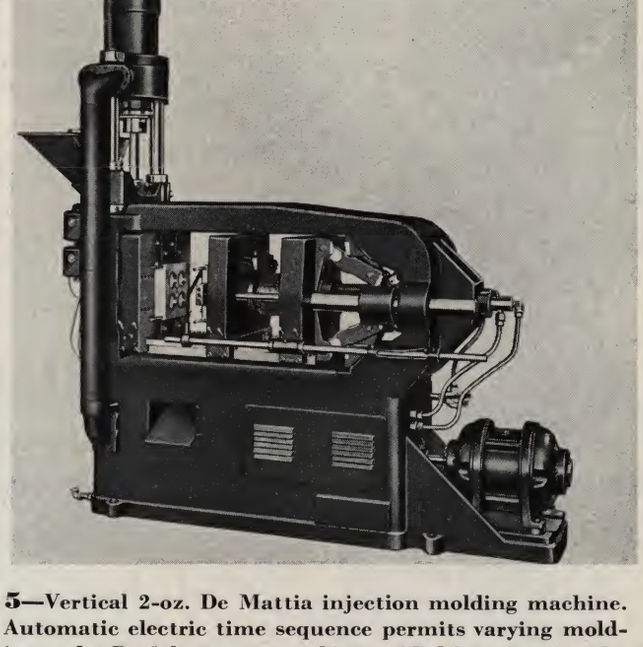
3—In cases where it is necessary to disassemble the heating cylinder to remove one type of thermoplastic material before using another, the single-cylinder will greatly reduce the time involved in this procedure.

The limitation in application of the single-cylinder injection molding press cannot be visualized today due to the constantly changing characteristics of molding materials with regard to flow and plasticization temperature. Simplicity of operation must be the watchword in injection molding machines, with the thought of definitely establishing the limitation of single-cylinder injections before resorting to the more complicated or complex methods of obtaining larger castings to meet the demands of the trade.

5



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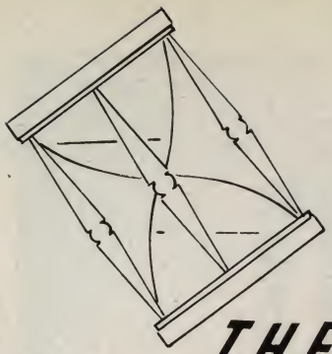


5—Vertical 2-oz. De Mattia injection molding machine. Automatic electric time sequence permits varying molding cycle. Push button control is provided for operating the unit. 6—Lester injection machine incorporating reducing valve for pressure control. Cam lubrication and positive wedge action toggle lock. (Photo, Index Machinery Corp.)

Multiple-unit injection presses

Multiple-injection machines make practical the molding of articles having very large areas, mass, and also intricate shapes. Weights expressed in pounds rather than ounces are now commercially practicable.

There are a number of reasons for believing that the plasticizing capacity of a single-injection heating chamber is relatively limited. New materials with molding characteristics requiring higher temperatures, increased



. . . . THE Past Record OF THE Lester AUTOMATIC INJECTION MOLDING MACHINES

LESTER Injection Molding Machines have led in the development of improvements and innovations which have been an important factor in the rapid progress made by the plastic molding industry. Their outstanding performance in the plants of leading plastic molders of America has helped make it possible for the industry to write a brilliant record of achievement during the past few years. And this performance of the past is a promise of even greater progress in the future—progress that will help carry plastic molding to greater achievement than ever before.

In keeping with the modern trends of molding materials, Lester has designed standard machines to produce full capacity castings from any of the commercial injection molding materials in use today. With a Lester Machine, the molder has complete freedom in matching the molding material to the requirements of the castings —not to the limitations of the machine.

The operation of the machine affords many unusual advantages. Pressures required for various castings are easily met. Vertical cylinder construction of the Lester Machine accomplishes results at *moderate pressures* for which conventionally designed machines frequently require pressures at considerably higher stages. Thus Lester eliminates many of the hazards associated with extreme pressures for satisfactory results.

Simple, easy access is provided for cleaning. The heating cylinder swings completely away—broken sprues and a clear opening to the rear of the mold is thus also provided. Rapid mold adjustment is made possible through patented worm and worm wheel. Heavy toggles and pins, cast steel beams across the top and bottom of the machine produce a veritable box-like construc-

Model No. 1	Model No. 2	Model No. 3	Model No. 3-S
Capacity 4 ounces.	Capacity 6 ounces.	Capacity 8 ounces.	Capacity 12 ounces.
Pressures on material, 16,000 lbs. to 20,000 lbs.	Pressures on material, 20,000 to 22,000 lbs.	Pressures on material, 16,000 to 22,000 lbs.	Pressures on material, 14,000 to 30,000 lbs.
Speeds, 126″ to 198″ per minute.	Speeds, 165″ to 211″ per minute.	Speeds, 131″ to 180″ per minute.	Speeds, 153″ to 170″ per minute.
Casting area, 40 sq. in.	Casting area, 60 sq. in.	Casting area, 100 sq. in.	Casting area, 100 sq. in.
Closing pressure, 225 tons.	Closing pressure, 300 tons.	Closing pressure, 400 tons.	Closing pressure, 400 tons.
Size of die plates, 20″ x 22″.	Size of die plates, 20″ x 22″.	Size of die plates, 21″ x 25″.	Size of die plates, 21″ x 25″.
Automatic cam lubrication.	Automatic cam lubrication.	Automatic cam lubrication.	Automatic cam lubrication.
Safety guards.	Safety guards.	Safety guards.	Safety guards.
Speed and pressure control valves.	Speed and pressure control valves.	Speed pressure control valves.	Speed and pressure control valves.
Higher pressures also available.	Higher pressures also available.	Higher pressures also available.	Higher pressures also available.

INDEX MACHINERY CORPORATION

2711 Church Ave., Cleveland, O.
49 Central Ave., Cincinnati, O.

Machine of the Future

tion. Flash due to stretching of structural members is thus practically eliminated.

Operating flexibility is another important advantage. In this, the Lester machine truly excels. The unanimous acclaim of molders the country over attest to the value of this extraordinary feature. Complete control of both the pressure and speed of the injection is accomplished through pressure reduction and volume control valves. The adjustment of each one is accomplished without affecting the setting of the other. Thus, simple and dependable control is provided over speed and pressure—two of the most vital factors involved in injecting various thermo-plastic materials.

Find out how Lester equipment can contribute to your progress in the plastic molding industry. Our engineering department will gladly submit production estimates without obligation. Write us for a complete catalog and details—learn why the industry has accepted the Lester machine as the ideal machine for dependable and trouble free operation to meet present day rigid production demands.

50% . . . of all sales resulted in repeat orders.

. . . of customers sold during first 10 months of 1940 were new users of Lester machines.



Capacities available—4 to 12 ounces standard. Special machines of varying capacities built to order.

REPRESENTATIVES

J. C. Austerberry's Sons, Detroit and Chicago
Standard Tool Co., Leominster, Mass.
The Phoenix Machine Co., Cleveland, Ohio
Dugan-Campbell & Company, Akron, Ohio
Burrough's Engineering Co., Newark, N. J.
Erick-Gross Corporation, New York City, New York
Moore Machinery Co., Los Angeles and San Francisco, Cal.

LESTER EUROPEAN SALES: Dowding & Doll, Ltd. 3 The Green, Wimbledon Common, S.W. 19, London

injection pressures and increased injection speeds place still greater demands on the power capacities of the machine. However, regardless of the ultimate limiting capacity of a single unit, practical operation during the past year has shown the need for injecting certain articles from more than one plastic source. This has pertained even in molding parts within the weight limit of existing single-unit heating chambers of injection presses.

As an example of the foregoing is an article of extended area and thin sections. Attempts to mold with a single unit even though gated at several points along one side, result in incomplete filling of the cavity. Injecting with two units from opposite sides provided the solution.

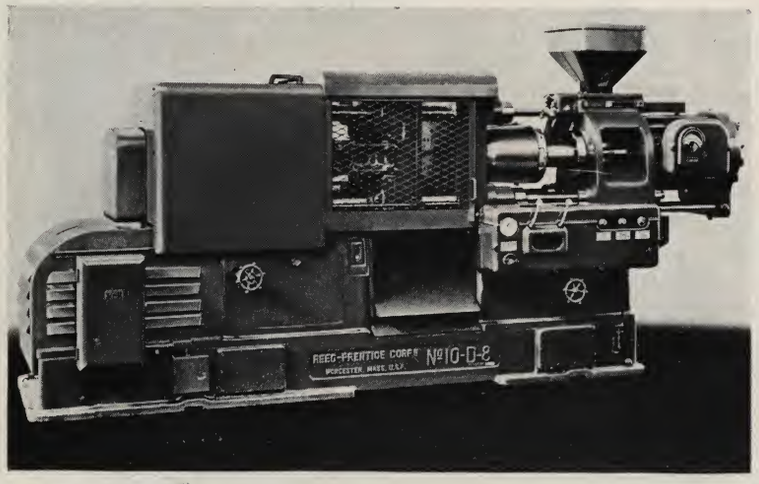
When molding a large piece, the material must divide as it flows into the mold spaces, later to re-unite with a welding of the material taking place. Full strength at the weld and avoidance of weld marks require that the material be entirely plastic at the instant of welding. Naturally, the further the material must flow within the chilled mold the colder and less plastic it becomes before welding can occur. The advantage of decreasing this distance is obvious. Multiple-injection at different points on the periphery of the piece will definitely accomplish that.

In some cases it is found essential to independently control the amount of plastic injected by each unit, providing more from one than another, according to the shape or other characteristics of the piece produced. The use of multiple-injection introduces many new possibilities as yet untouched commercially—as for example—multi-color molding.

Altogether, multiple-unit operation extends the use of thermoplastics to many products hitherto made of metal, wood or other materials.

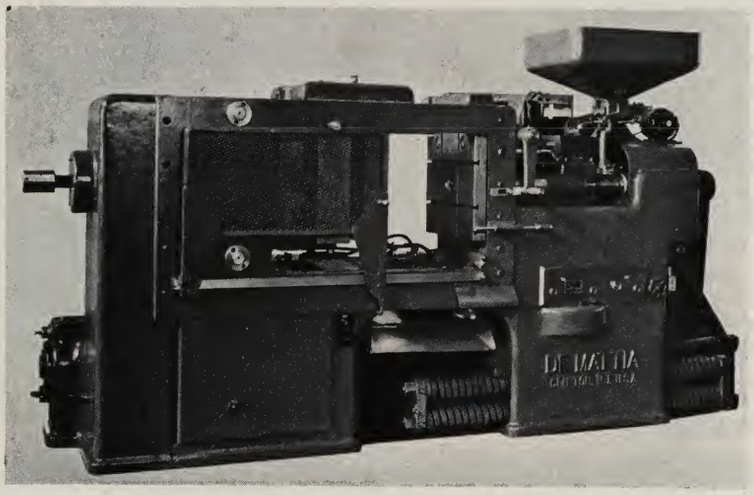
Many of the advantages of multiple-injection molding are found in the perfected design of the machine itself. These are revealed in a consideration of its features.

As with any injection machine, two major functions are performed, namely, clamping the mold halves together and injecting the plasticized material. In the case of the multiple unit machine the mold clamp is a vertical, downward-acting hydraulic platen press. The stationary half of the mold is carried by the lower table or bed. The movable half is attached to the face of the press platen actuated by the direct-acting hydraulic ram. This moving platen is guided by adjustable tapered gibs. Their only function is to provide accurate mating of the two mold halves. None of the weight is imposed on the guides as with a horizontal type of die clamp. Naturally, as molded articles increase in size, mold size and weight will increase tremendously, which in no way is limited with this type of press. Presses of suitable type have already been developed with die space ample to take molds as large, for example, as the entire side of an



7

7—Reed-Prentice 10 D 8-oz. injection molding machine. Magnetic heating provides uniform heat throughout cylinder. Rigid toggle lock construction reduces load on toggle pins



8

8—Of sturdy construction this De Mattia machine has 8 oz. capacity. Coiled springs provide adequate lock pressure. Closing pressure reduces flashing to a minimum

THE CARVER LABORATORY PRESS

➡ is a MUST for Molding

Conditions of actual production can be duplicated on this compact, powerful laboratory hydraulic press. Plastic moldings and samples may be produced of both thermoplastic and thermosetting materials. Tests for pressure, temperature, and time of molding may be taken. Press is good for up to 20,000* pounds and a large accurate gauge provides for checking pressure. And specially designed electric hot plates are available (for temperatures up to 400° F.) fitted with thermometer pockets for reading temperatures. Steam hot plates can be furnished, too, complete with flexible metal hose connections for steam and water.

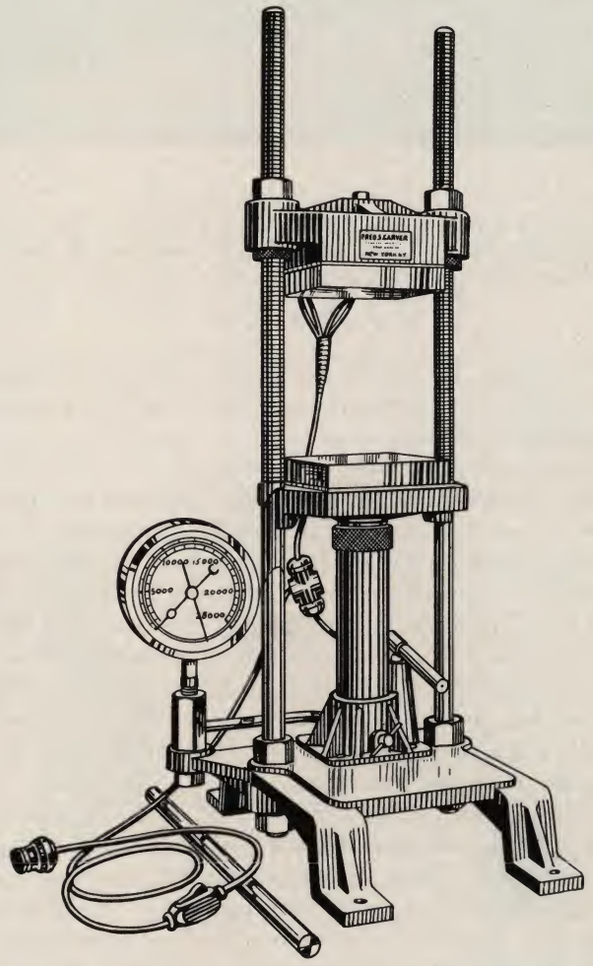
The press is ideal for plastic flow, extrusion and lamination tests. With standard accessories it provides for filtration, dehydration and crushing tests, for general research in the laboratory.

All of these tests reproduce the conditions of plastic production, in miniature, and without the *expense* of production! This is the main reason for the wide use of the Carver Laboratory Press in the plastics industry. It saves money by allowing accurate small-scale experimentation with the various phases of producing and molding plastics.

The Carver Laboratory Press is extremely light (a man can lift it) yet so sturdy that they have been in use upwards of 12 years without mechanical failure. Molders, material plants, laboratories, colleges,



universities and Government Bureaus use hundreds of these presses for nearly 60 purposes. Hydraulic, hand operated, self-contained. Just plug into any light socket and go to work.



➡ WRITE FOR *COMPLETE* CATALOG AND PRICES

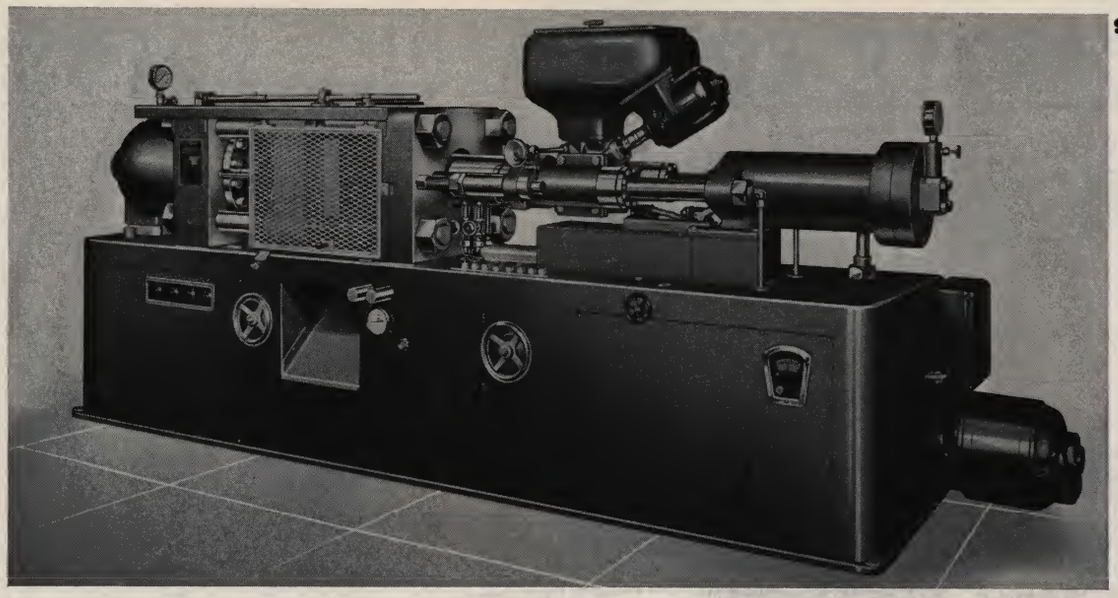
Can be had for 40,000 pounds, on order.

THE CARVER LABORATORY PRESS

FRED S. CARVER
HYDRAULIC EQUIPMENT

★

343 HUDSON STREET, NEW YORK
IN LONDON: Baker Perkins, Ltd.



9

9—Self-contained horizontal acting injection press by Hydraulic Press Mfg. Co. with straight line hydraulic clamp for opening, closing and sealing mold halves. Material is heated by circulating fluid heat with automatic temperature control

automobile. If there are limitations in the extent of application of injection molding, it is certainly not in the molding machinery.

The hydraulic system for operating the mold clamp ram provides means for closing the mold quickly, once the cycle has been started. During this rapid-traverse forward movement of the large clamp ram, its cylinder is prefilled with oil (used as the hydraulic operating fluid) from an overhead tank. This oil supply is mounted directly on top of the cylinder. Communication between tank and cylinder is through a special automatic valve built into the cylinder head, not unlike an automobile engine poppet valve but very much larger and heavier than that type valve.

With direct hydraulic ram action, molds of various heights may be accommodated without press adjustments. Any desired pressure within the capacity limits may be applied at any closing position. The pressure required to hold a mold without flashing is determined by gages indicating tons total load. Although the vertical die opening exceeds the maximum ram travel, accidental overstroking without dies in place is made impossible by full tonnage stop rods.

As soon as the molds are closed, clamp pressure is built up by a radial-type oil pressure pump, which delivers directly to the clamp cylinder. This radial pump and its direct-coupled driving motor are mounted on the head of the clamp press frame. The pump is a variable delivery, multiple-piston type. The hydraulic clamping force is positive and continuous, the hydraulic power of the pump being applied at the rate of 100 impulses per second, a frequency more than 50 percent higher than that of standard alternating electric current.

The clamping pressure is subject to accurate regulation according to the requirements of each particular mold. This involves merely one simple hydraulic control setting—no fussy mechanical adjustments of die clearances, etc. This control acts on the variable stroke mechanism of the pump itself. It embodies a spring of adjustable compression, tending to maintain the pump on full stroke and a hydraulic plunger acting in opposition. The pump output pressure applied to this plunger will compress the spring and move the pump toward neutral. The pressure required to do this is governed by the setting of the spring. While the molds are held closed the pump is consuming very little power, delivering the required pressure but at practically zero volume.

The injection unit

Each injection unit is a complete self-contained mechanism, with facilities for: (a) Feeding the material of original granular form in properly proportioned amounts; (b) Heating the material to plasticity; (c) Injecting molten plastic into cavities of the closed chilled mold.

A supply of the material is contained in a closed hopper from which a worm-feed screw conveys it into a first section of the injection chamber. This section is cooled by water circulating in a jacket to prevent the material from prematurely heating and sticking. The feed screw is driven by an electric torque motor through an enclosed gear train. The amount of material fed is harmonized with the machine's plastic consumption. This is accomplished by regulation of the number of revolutions of the torque motor per operation together with its frequency of operation.

From the feed chamber the material is forced by a plunger into the adjacent heated injection chamber, the passage through them being a continuous one.

(Please turn to next page)

Low-Cost Machines For Plastic Plants



No. 1370—Floor type 17 Inch "Slo-Speed" Delta Drill Press with No. 2 Morse Taper Spindle and Standard Tilting Table.

If you are confronted with an urgent need for a quick increase in production capacity—you should, *at once,* check into the possibility of utilizing the new low cost Delta machines. These remarkably efficient and flexible machines are in active use in thousands of industrial plants all over the world—as production line equipment—auxiliary machines—special set-ups—and in tool rooms. Their first cost is low—their operating costs are low—they are sturdy, accurate and easily adaptable to your special needs. Above all—you can get immediate delivery on them—RIGHT NOW!

Send for CATALOG....

It will pay you to investigate carefully—learn the full possibilities of these quality units that are affecting a revolution in present-day production methods. Fill out the coupon and send for the complete catalog of Delta low-cost drill presses and other machines.

DRILL PRESSES

Delta low-cost 2 spindle, 4 spindle, 8 spindle, 14" and 17" drill presses—are helping cut costs and speed production in many thousands of manufacturing plants. Also available are the new Delta sectional drill press units which give you as many spindles as you need—spaced as you need them—at astonishingly low cost.

Abrasive Finishing Machines



Finishing, polishing, edging and burring of small parts are all speeded up with the new Delta Abrasive Finishing Machine. Completely flexible in operation, this surfacer can be used vertically or horizontally, used with simple stop for small work or with accurate 7⅜" x 14¾" tilting table and miter gauge for precise finishing. Requires no lubrication. Has many uuusual features. Also available—the Delta motor-driven and belt-driven disc abrasive finishing machines that give long service and accurate, dependable work.

Metal-Cutting Band Saw



Takes the place of a power hacksaw in cutting off bars and shapes; it is used in the tool room for sawing off tool, die and fixture stock; it will cut uniform strips from sheets; it saves hours of time in cutting templates and similar tools, and will cut almost any material, such as asbestos, mica, vulcanite, fiber, etc. Four low metal-cutting speeds and one high speed for wood sawing.

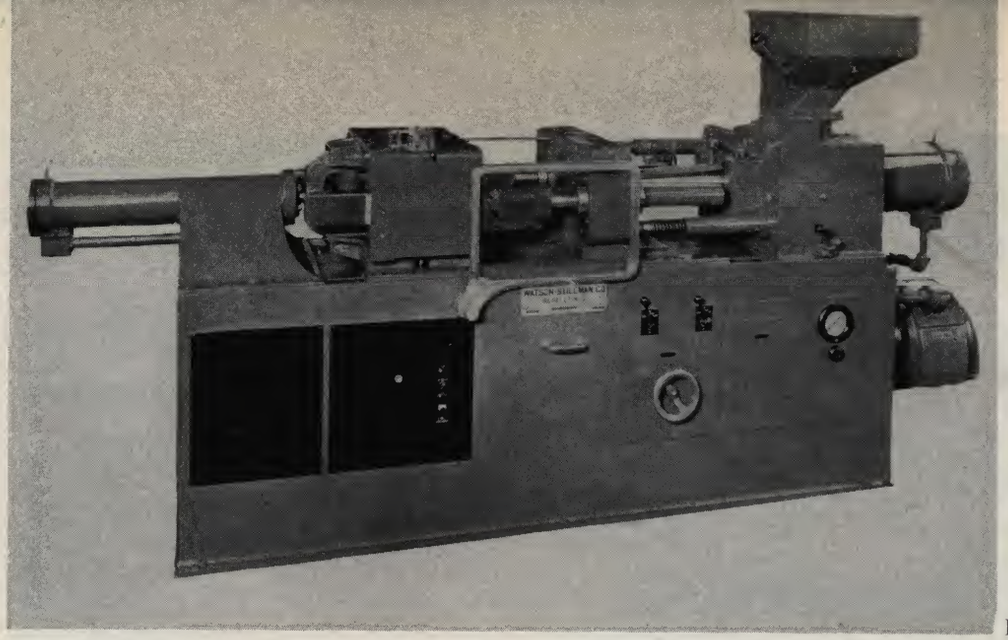
Pedestal and Bench Grinders



Not just another line of grinders—but revolutionary grinders in every sense of the word. From their Twin-Lite Safety Shields to their Double-Seal Ball Bearings, these new belt-driven and motor-driven and pedestal models all embody Delta's high standards in design and construction. Belt-driven grinder can be driven from motors of any voltage, phase or horsepower.

DELTA MANUFACTURING CO.
(Industrial Division)
673 East Vienna Ave.
Milwaukee, Wis.

DELTA MFG. CO., (Industrial Division)
673 E. Vienna Avenue, Milwaukee, Wis.
Please send me catalog of Delta Machines, giving specifications and prices on the complete Delta drill presses.
I am also interested in: ☐ Metal Cutting Band Saw, ☐ Delta Grinders, ☐ Delta Belt and Disc Abrasive Finishing Machine.
Name_____
Address_____
City_____ State_____



10—Watson - Stillman Co. 6-oz. injection molding press. Positive clamping mechanism provides for quick and easy adjustable variation of mold thickness. Adaptor type nozzle permits replacement at a critical point of wear

10

The material is heated progressively as forced through the chamber, quickly becoming plastic. For most effective heat transfer, the material is spread out in an annular passage formed by the outer wall of the chamber and a central core. Approach to the outlet nozzle is via a series of converging holes which further aid final heating.

The plunger which forces the material through is actuated by a double-acting hydraulic piston, reciprocating in a smooth bore cylinder. This piston is operated by a hydraulic oil pressure of 2000 lbs. per sq. in., maximum. With a 10 to 1 ratio of piston to plunger areas (and a corresponding multiplication of unit pressures) an injection pressure of 20,000 lbs. per sq. in., maximum, is developed. Still higher injection pressures may be provided for plastics that require it, by construction of the injection unit with a greater piston/plunger area ratio.

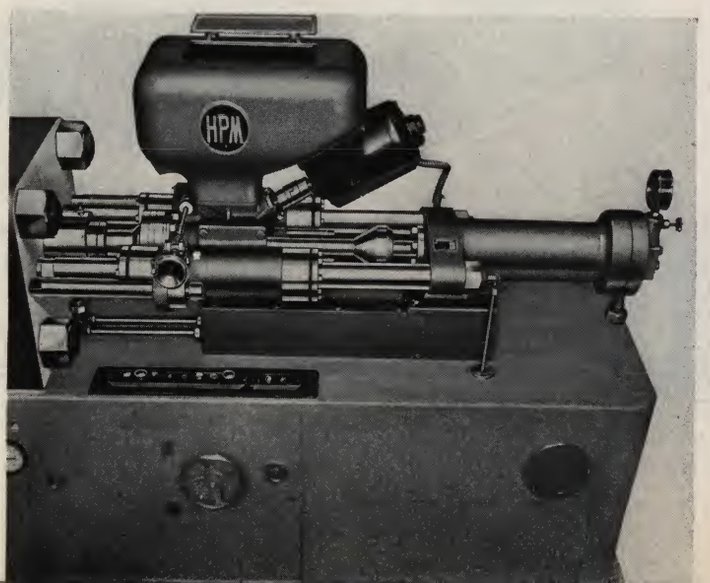
Each of the injection nozzles contact the mold along its edges and center on the parting line, which in this case, is in the horizontal plane. The gates are entirely open on the face of the lower mold, hence are particularly accessible for easy cleaning.

The nozzles are held in positive contact with their mold inlets by hydraulic pressure from a pair of auxiliary hydraulic pistons. These are double-acting, and engage the entire injection unit, traversing it to and from the mold along its tension rods. At the end of the cycle each unit moves back, slightly withdrawing its nozzle from contact with the mold, thus breaking off the sprue. The unit-traversing pistons have a much greater total stroke than is employed for normal cycle movement. This can be utilized to entirely withdraw a unit to obtain complete accessibility in servicing.

Each injection unit is a completely independent mechanism with its own individual source of hydraulic power. This consists of a variable delivery radial plunger pump with automatic stroke-regulating pressure control. Both pump and control are identical in type to that which serves the clamp press (as previously described) but of greater displacement. The pump output passes through a balanced piston valve which controls the action of the injection piston. The complete injection units are grouped in pairs at either side of the clamp press. They are joined with the press frame through their tension rods connecting into heavy steel yokes at the frame end.

Within the pedestal supporting each pair of units are two complete heating and circulating systems for the fluid employed in heating the injection chambers. The fluid is heated by electric immersion elements of special characteristics for the service. The temperature is accurately controlled by automatic thermostat-actuated switches. The hydraulic power units for the injection units are also arranged in pairs at the extreme ends, with

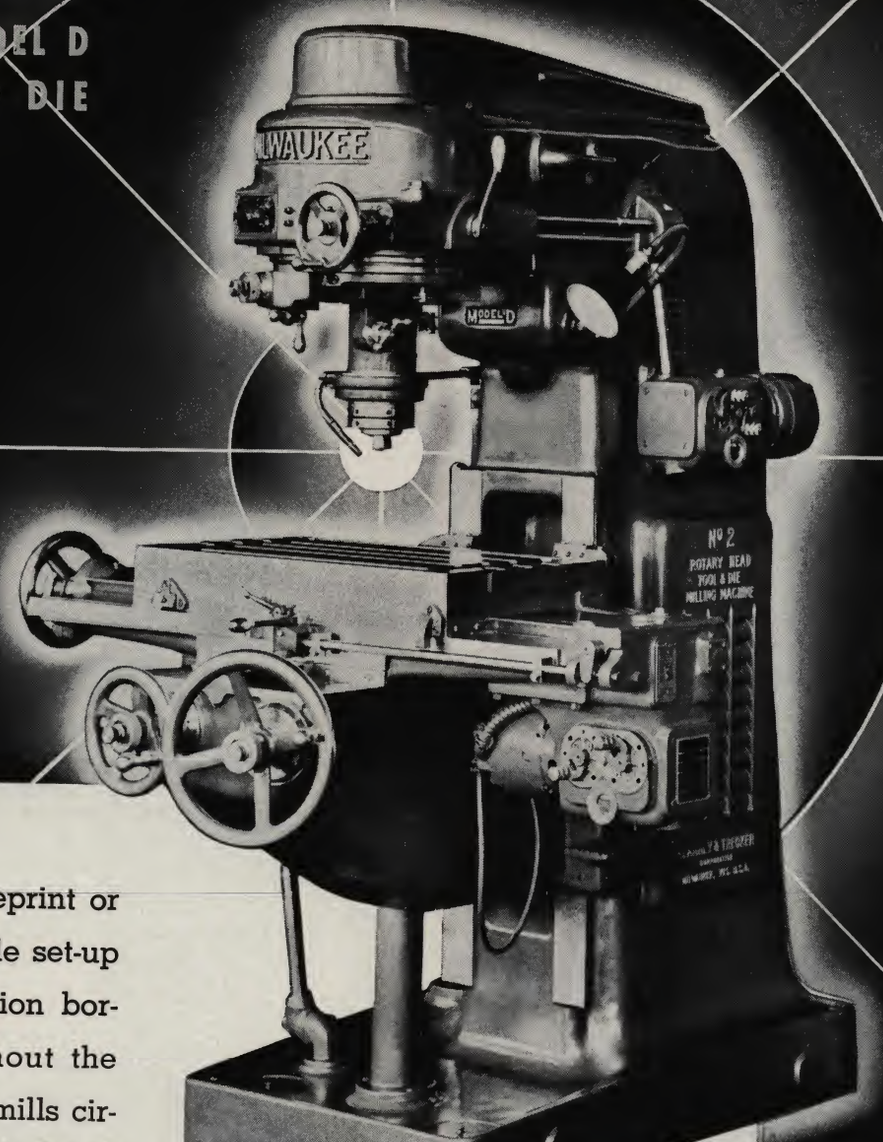
11



11—View of material hopper. Feeding section and injection ram housing for horizontal type multi-cylinder machine. On larger presses multiple groups of these units are installed. Through synchronizing the operation either way large pieces or several pieces may be molded in one operation

MAKE PRECISION DIES, HOBS, MOLDS *more rapidly-more accurately* IN A SINGLE SET-UP

WITH THE MILWAUKEE MODEL D ROTARY HEAD TOOL AND DIE MILLING MACHINE



A MACHINE that transmits blueprint or drawing into steel—in a single set-up — layout, milling, drilling, precision boring and slotting operations without the use of models and templates . . . mills circular and angular cuts in both vertical and horizontal planes — completes dies, hobs, molds without resetting of machine and with unprecedented speed and accuracy . . . Send for Bulletin No. 1002 giving full information on the Milwaukee Model D — Rotary Head Tool and Die Milling Machine.

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MILLING MACHINES

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MILWAUKEE, WISCONSIN, U.S.A.

a double-end shaft motor driving two radial pumps.

All functions of the entire machine are automatically controlled and in timed and coordinated sequence to properly carry out the entire injection molding operation. This is all accomplished electrically, through electric operators for the hydraulic valves controlling the die clamp and each injection unit, together with the individual motors driving the material feeds of the injection units. The operator's control is through panels of electric push-buttons and selector switches. In addition to the press action controls, all of the manual controls for driving motors, and the electric heating and circulating system are centralized at the operator's position. Any of the four injection units may be cut out of service whenever required.

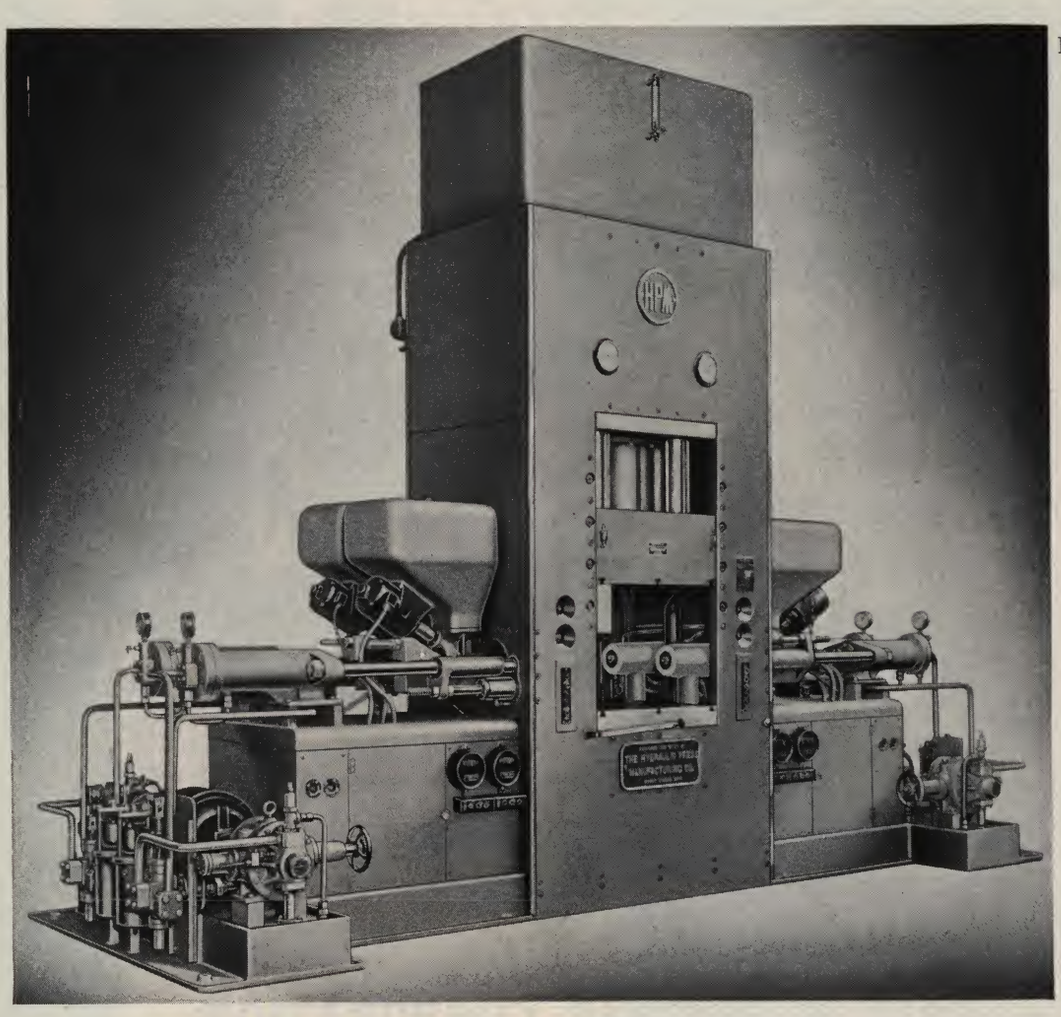
Regular operation is on a semi-automatic basis, started by push-buttons and continuing automatically through every step until completion with the opening of the mold and ejection of finished product. The clamp press ram may be controlled independently in its movements by a hand lever. This is particularly convenient for the initial setting of the die.

That the art of injection molding has been greatly extended through this practical development of the multiple-injection unit system is now certain. Furthermore, it is clear that there is no conflict of single versus multiple injection. Both have their place in the industry. Whatever improvements the future brings in the individual mechanism, whatever its ultimate plasticizing capacity may become, all of the advantages of the single-unit may be extended by the operation of such units in multiple.

The advances which have been made in injection machines have developed along several principal avenues. The demand for increased capacity has arisen from two sources, greater production of certain size pieces, and larger size pieces.

In the case of producing a greater number of parts during a given period of operation this has been accomplished by stepping up the cycle through faster mold opening and closing. The individual size of moldings is at the moment, at about the maximum which industry seems to be requiring, for in the very large pieces weighing over 16 oz. there are few new applications appearing.

Probably no part of an injection machine is more important than the heating cylinder. Because this is so, all manufacturers have given this problem extensive consideration. Many types of heating are being used, among them oil, induction and magnetic. In each instance advances of importance are being made with the result that continually larger quantities of thermoplastic materials may be plasticized in increasingly shorter space of time. Heat control is also being perfected and loading devices are being held to more precise performance. Safety is also playing a factor.



12

12—This H-P-M multiple unit injection press machine has a rated capacity of 36 oz. It consists of a vertical downward acting press in which the molds are clamped. There are two injection units on each side of the press. Direct hydraulic pressure clamping provides follow-up pressure under heavy load

INJECTION PERFORMANCE



KNIFE—Fruit Knife—Handle 1/2" thick to extreme knife edge. Overall length: 18". Material: Crystalite.



TEST PIECE—Weight: 8 oz. 144 sq. in. projected area—3/32" thick. Material: Crystalite.



DOLL—Molded of Acetate. 5/8" through thickest section. Weight: 10 ounces.

N.B. These moldings produced by Plastics, Inc., Avon, N. J.

Experienced Molders Will Appreciate the Versatility of De Mattia Injection Molding Presses as evidenced by these moldings.

New DE MATTIA 8 oz. capacity injection molding press. Featuring: 500 ton clamping pressure. Minimum floor space — 36" x 142". Controlled Injection Pressure.

•

Our complete line of equipment for injection molding includes presses from 2 oz. to 8 oz. capacity, scrap grinders, molds.



DE MATTIA MACHINE and TOOL CO.

CLIFTON, NEW JERSEY

Eastern Representatives:
Brosites Machine Company
30 Church St., New York City

Laboratory presses

NOT long ago, somebody said it was getting so that whenever a chemist got an accidental reaction and found a sticky mess in his retort, he would immediately get busy to see whether he hadn't found another new plastic. This was probably quite true and is still going on, more than we know.

But today there are many plastics, of many desirable characteristics, colors, and applications, for different uses, highly developed and still developing in ever-broadening fields. Not only development of these plastics, but of their applications and uses in producing a multitude of new things, goes on continually, and in these fields laboratory presses play a most important part.

Laboratory presses have been developed and used which enable the chemist, the research man, and the production man, who work out, develop, and control the characteristics and uniformity of the different plastics, to run actual small scale molding tests in the laboratory, on samples and control batches. These same presses provide, too, for making molded samples of finished pieces, first through experimental production in single cavity molds, and often production in small scale multiple cavity molds, up to the point of sales.

Then if the product is right, it is ready for quantity production in the plant, by means of large presses and multiple cavity molds for large scale plastic molding.

These small laboratory presses have been designed so that openings are quickly adjustable by hand to suit different experimental dies. They are provided with electric hot plates to suit the thermosetting materials, or with steam hot plates, which provide for steam heating and water cooling, to suit the thermoplastic materials.

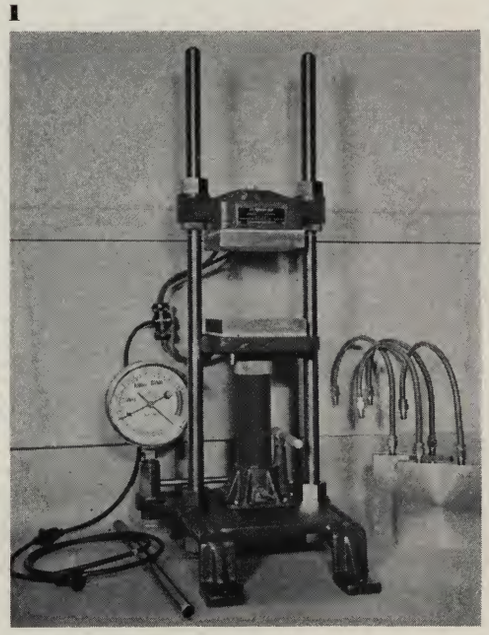
It is important that the presses be hand-operated, provided with pockets for laboratory thermometers, large accurate gages, and hydraulic means such that moldings may be made accurately under varying conditions of pressure, time, and temperature, as required. And for these purposes, within limits, the smaller the press the better, because of its ease and speed of operation and adaptability for many purposes.

It will be seen that with such a press, small scale tests are made and samples produced which mean much in guiding and controlling further operations. Not only molding, but extrusion and plasticity tests, laminations, etc., and even crushing or breaking tests, may be run on the same machine.

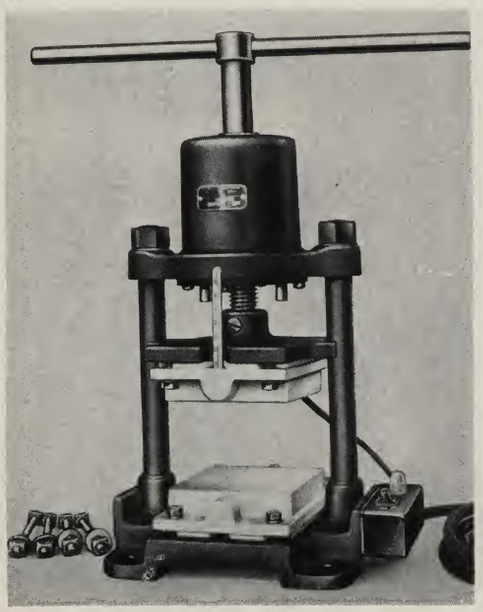
There is perhaps no absolute dividing line between the laboratory press and the production machine. Larger presses are, of course, often required in the laboratory. However, these are usually production or semi-produc-

1—Small laboratory presses are the chief means for molding research samples and also serve for running production control tests. This 10-ton hydraulic unit manufactured by Fred S. Carver has electric and steam platens for both thermoplastic and thermosetting materials. 2—S. S. White electrically-heated screw-type laboratory press with thermostatic temperature control is used mainly for pressing denture bases by the dry heat technique. 3—Self-contained two-rod, upward acting platen press—designed for plastic laboratories by Hydraulic Press Mfg. Co.

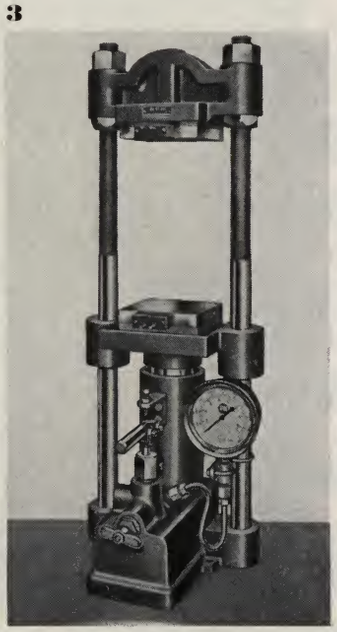
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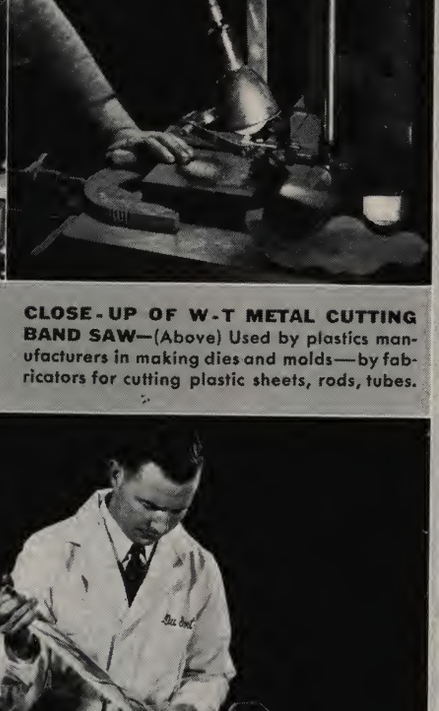
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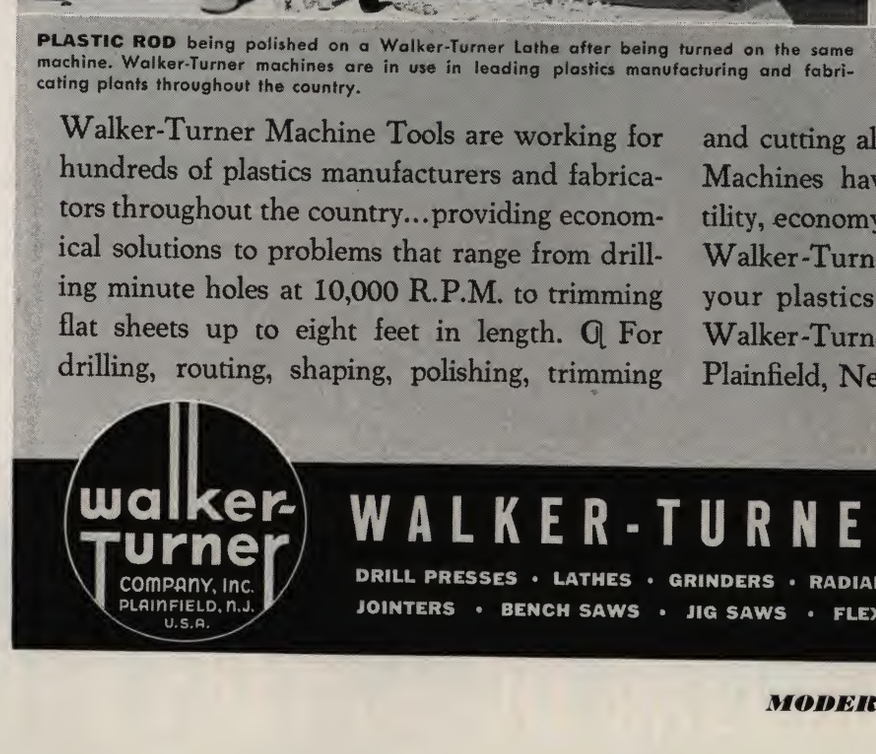
"NATURALS" for the PLASTIC INDUSTRY



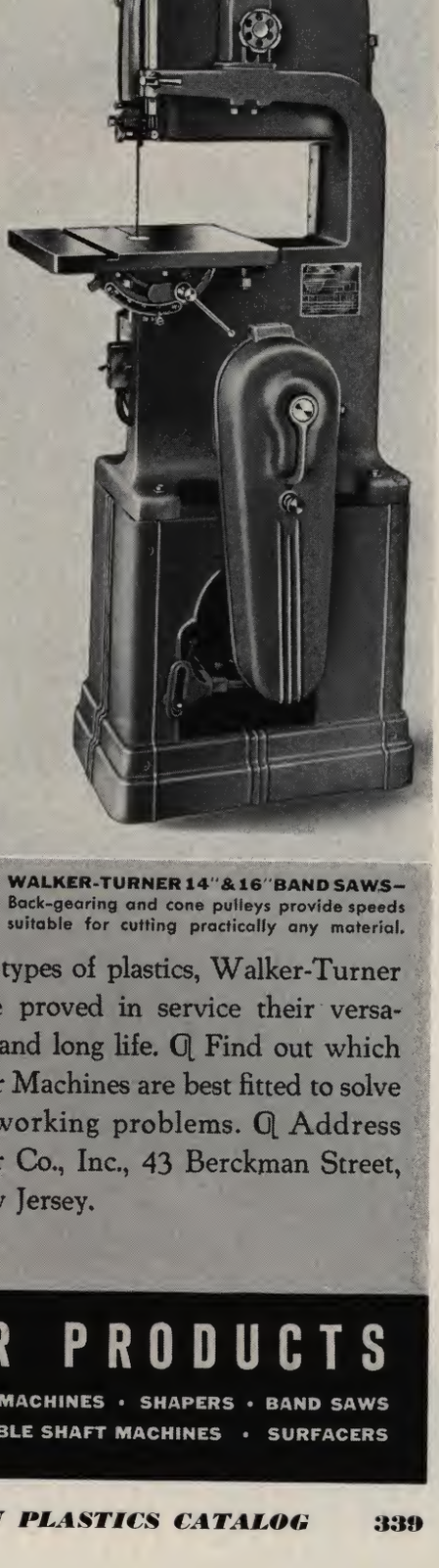
WALKER-TURNER RADIAL SAW—(Above) Used by plastics manufacturers and fabricators for cutting, mitering, shaping, routing, etc., sheets, rods, tubes of both metal and plastics.



CLOSE-UP OF W-T METAL CUTTING BAND SAW—(Above) Used by plastics manufacturers in making dies and molds—by fabricators for cutting plastic sheets, rods, tubes.



PLASTIC ROD being polished on a Walker-Turner Lathe after being turned on the same machine. Walker-Turner machines are in use in leading plastics manufacturing and fabricating plants throughout the country.



WALKER-TURNER 14" & 16" BAND SAWS—Back-gearing and cone pulleys provide speeds suitable for cutting practically any material.

Walker-Turner Machine Tools are working for hundreds of plastics manufacturers and fabricators throughout the country...providing economical solutions to problems that range from drilling minute holes at 10,000 R.P.M. to trimming flat sheets up to eight feet in length. ¶ For drilling, routing, shaping, polishing, trimming and cutting all types of plastics, Walker-Turner Machines have proved in service their versatility, economy and long life. ¶ Find out which Walker-Turner Machines are best fitted to solve your plastics working problems. ¶ Address Walker-Turner Co., Inc., 43 Berckman Street, Plainfield, New Jersey.

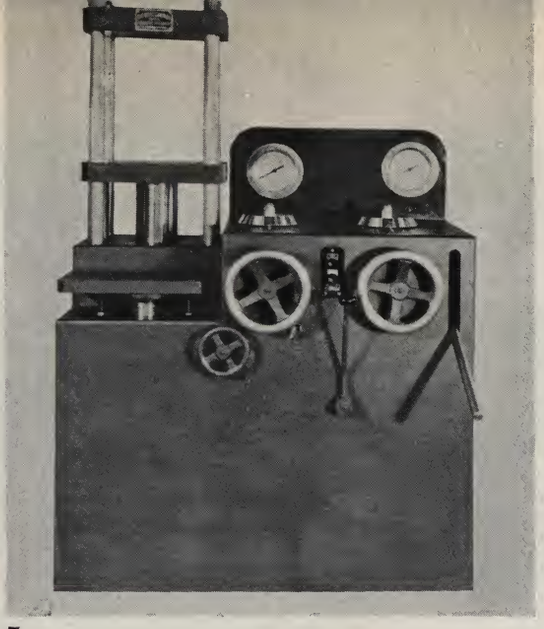
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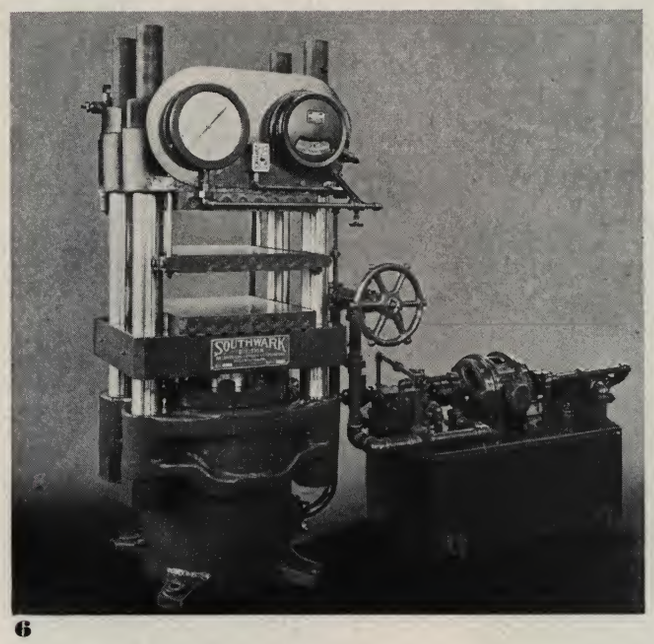
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4



5



6



7

4—Freneh Oil Mill Maehinery Co. 50-ton laboratory press—aeeurate temperature and pressure recording instruments insure elose readings. 5—R. D. Wood Co. 30-ton laboratory press equipped with northern rotary piston pump and single plunger hand pump. 6—Self-contained 200-ton steam platen Baldwin-Southwark press of produetion eapacity equipped for laboratory work on either small seale or regular size pieees. 7—Cabinet-type self-contained press by Charles F. Elmes Engineering Works, for quantity produetion with minimum maintenanee eosts

tion machines, necessarily used in the laboratory when the tests and research work are run on pieces which are particularly large in size.

But in general we think of the laboratory press as the one best adapted to quick, accurate, small scale tests in the laboratory. And it will be plain that in plastic molding, facts of a test on a few square inches of mold area, or a few cubic inches of material, may be quite accurately translated into large scale operations.

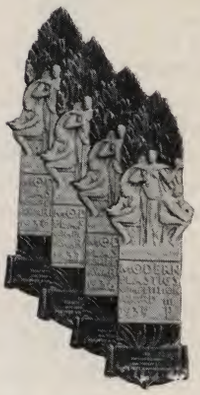
When the required load, time, temperature, etc., are known, for molding a single piece in a single cavity die, then the multiple cavity die and capacity of the large production press for the particular piece can be accurately calculated to best advantage.

In many cases these little presses have been used in actual quantity production with multiple cavity dies for making such things as unbreakable watch crystals and various other small pieces.

In some of the largest plants where there are great installations of production presses, the little laboratory presses are needed just the same, and found most useful. For instance, one of the largest concerns has something like a dozen of them in its different laboratories and plants, for such requirements as samples, testing single cavity molds, and control work. The same is true of other large plastics producers, and of smaller firms and individuals producing plastics and plastics items who find the laboratory press invaluable.

FRENCH HYDRAULIC PRESSES

1936
1937
1938
1939



WINNER OF MODERN PLASTICS AWARDS *Four Years Straight*

Recognition of the consistent high quality performance of French Oil Hydraulic Presses brings the Modern Plastics award to this company four years straight. When considering modern press equipment for molding plastics consider the record set by French Oil Hydraulic Presses.

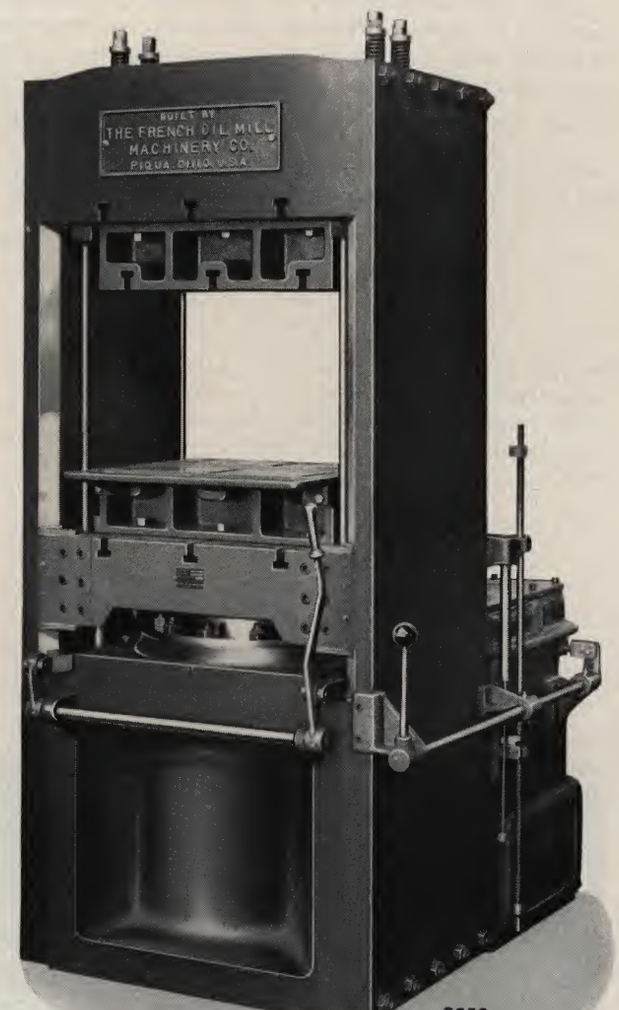
. . . the choice of Leading Plastic Molders

For accuracy, speed and economical operation that brings increased profits turn to French Oil Hydraulic Presses, the choice of leading plastics molders. Complete self-contained press with automatic time control that is instantly adjustable. Dependable modern French Oil Presses in sizes up to 1500 tons, for every plastic molding job and built to your particular requirements, will lower your production costs. Consult French Oil engineers or write for catalog.



The group installation of twenty self-contained French Oil Power Plastic Molding Presses.

French Oil also builds a standard accumulator operated press of many different types. As modern in results as in appearance.



HYDRAULIC PRESS DIVISION

THE FRENCH OIL MILL MACHINERY CO.

PIQUA, OHIO

Extruding machines*

DURING the past year, there has been an unusual interest on the part of raw materials manufacturers and fabricators requesting information on machines for the extrusion of plastics. The extrusion process is not new. Since the invention of the screw type extruding machine (or tubing machine) by Vernon Royle in 1880, such equipment has been in use, principally in the rubber industry, for producing tubes, rods and channels and for the covering of rollers and insulated wire.

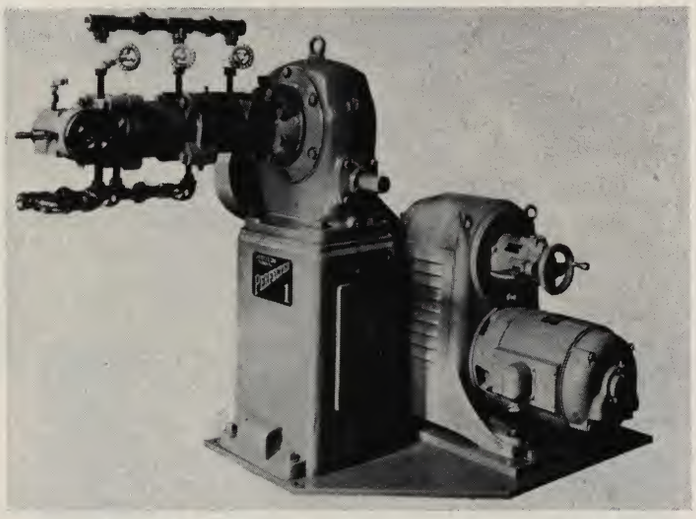
Fifty years ago, two of the applications of this type machine to plastic substances other than rubber were in the extrusion of casein rods from which button blanks were sawed and in the forming of continuous tubes of nitrate for pen barrels. Later, crude adaptations were made to meet the immediate needs of the fast-growing plastics industry and, until quite recently, no specifically designed machinery was available for extruding plastics.

Essentially, the screw type extruding machine consists of a horizontal cylinder containing a screw similar to that used in a butcher's meat grinder. At one end of the cylinder is a feed hopper, while the other end carries a die-supporting head. Material fed into the hopper is carried along and compressed by the closely fitted screw until it is forced through the die in a strip having the cross-sectional shape determined by the shape of the die. If it is desired to extrude a tube or hollow strip, a core of the proper size and shape is supported behind the die by a web-like bridge.

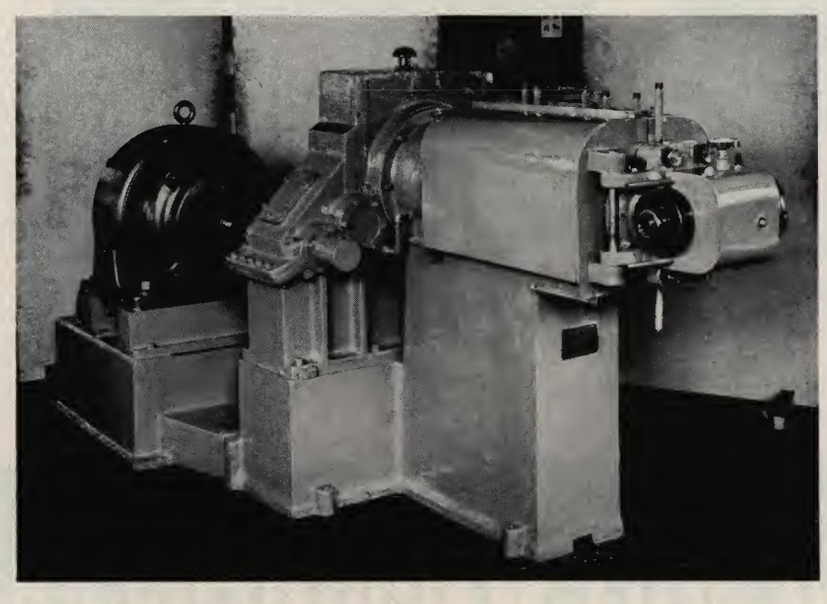
A coating may be forced upon a wire, tube or other section by using a cross-head. With a cross-head in

* This article was especially prepared for this issue by Kenneth Vandenbrez, John Royle & Sons.

1

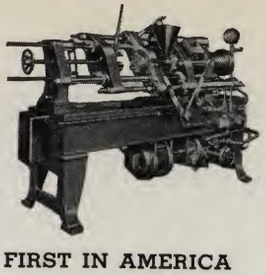


1—This 2-in. cylinder diameter extrusion machine is designed to allow ample masticating time in the cylinder. It is also arranged for providing the required heat for plasticizing on continuous runs. (All photos, courtesy John Royle & Sons)

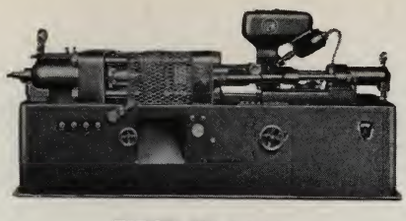


2

2—A large capacity screw type plastic extrusion unit having a 3¼ in. cylinder diameter. It features one of the latest hinged type heads and includes self-lubricated gear reduction



FIRST IN AMERICA



FIRST IN 1941

PLASTIC INJECTION MOLDING PRESSES

Hydraulic power, directly applied, is employed for every pressure action of H-P-M plastic injection molding presses. This provides the molder with extreme flexibility of operation and ease of change-over from one job to another. Every function of injection molding is performed by H-P-M machines in a manner that is distinctively H-P-M. In sequence these are as follows:

H-P-M Positive Material Feed – A torque motor driven feed mechanism delivers the granular molding material to the injection chamber. All units of more than two ounce capacity have an enclosed force-feed screw, providing positive delivery of material to the chamber. Feeding is automatically proportioned to plastic output.

H-P-M Circulating Fluid Heating of Injection Chamber – At one end of the press, within the press base, is located the hot oil reservoir. Electric emersion type elements heat the oil in the tank to the desired temperature. A small H-P-M gear pump circulates this oil to and through the spiral passages of the chamber, then back to the tank to be reheated. An indicating instrument mounted in the press base panel permits the press operator to regulate the temperature of the oil as desired.

Through the H-P-M Circulating Fluid Heat, positive and accurate temperature control of the plastic in the injection chamber is assured. Thus plastics of delicate tints are readily handled without burning.

Circulating fluid heat is especially beneficial with large capacity injection molding presses. The H-P-M 2 oz. press is not equipped with fluid heat, but instead Calrod type electric heating units directly transfer heat to the plastic heating chamber.

H-P-M Hydraulic-Loaded Injection Nozzle – Positive connection between the injection chamber nozzle outlet and the mold inlet is provided by direct hydraulic means. No mechanical adjustments are required. The loading on the nozzle is uniformly maintained. The nozzle withdraws slightly automatically at the end of each cycle, breaking the sprue. Contact time of nozzle and mold is reduced, minimizing adverse heat transfer. For access to the nozzle a wide separation can be quickly obtained.

H-P-M Straight-Line Hydraulic Clamp – The H-P-M Plastic Injection Molding press exclusively features straight-line hydraulic force for the clamping of mold halves. Advance of the clamp platen to its closed position is accomplished by employing a hydraulic ram, metallic piston ring packed. Some important features of the straight-line hydraulic clamp are:

1. Easy die set-up.
2. Clamping force definitely known.
3. Few working parts – no links, toggles, wedges, etc.
4. Smooth operation.
5. Positive protection against overload.
6. Adjustable clamping force.
7. Unaffected by temperature changes.
8. Ample force to separate mold halves and operate knockouts.

H-P-M Radial Pumps and Control Equipment – Each H-P-M Injection machine is provided with two separate H-P-M Radial Pumps – one for the clamp unit and the other for the injection unit. Both pumps are driven from a single electric motor with double shaft extension. The H-P-M Radial Pump provides a constant pressure against the clamp ram with a minimum of power consumed due to its variable volume feature. An automatic control regulates this according to demand – maintaining the output near zero when the ram is stationary while holding full pressure of the molds. No chance for mold flash – the pressure is always right there. No waste of power as with constant volume pumps which must dissipate full horsepower through relief valves.

H-P-M – The Complete Line – A size for every molding job. H-P-M, the pioneer producer of injection machines in America, offers a line of machines that embraces every possible requirement for injection molding. A complete series of horizontal single unit machines of four basic sizes provide injection capacities from two to twelve ounces of plastic per cycle. Vertical machines with multiple injection units, in the creation of which H-P-M is world pioneer, provide for larger capacities, limited only by the ingenuity of the die maker and the practicability of the plastics themselves for extended applications.

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343

BULLETIN NO. 4109

THE HYDRAULIC PRESS MFG. CO., MOUNT GILEAD, OHIO, U.S.A.

District Sales Offices: New York, Syracuse, Detroit and Chicago
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2 OUNCES

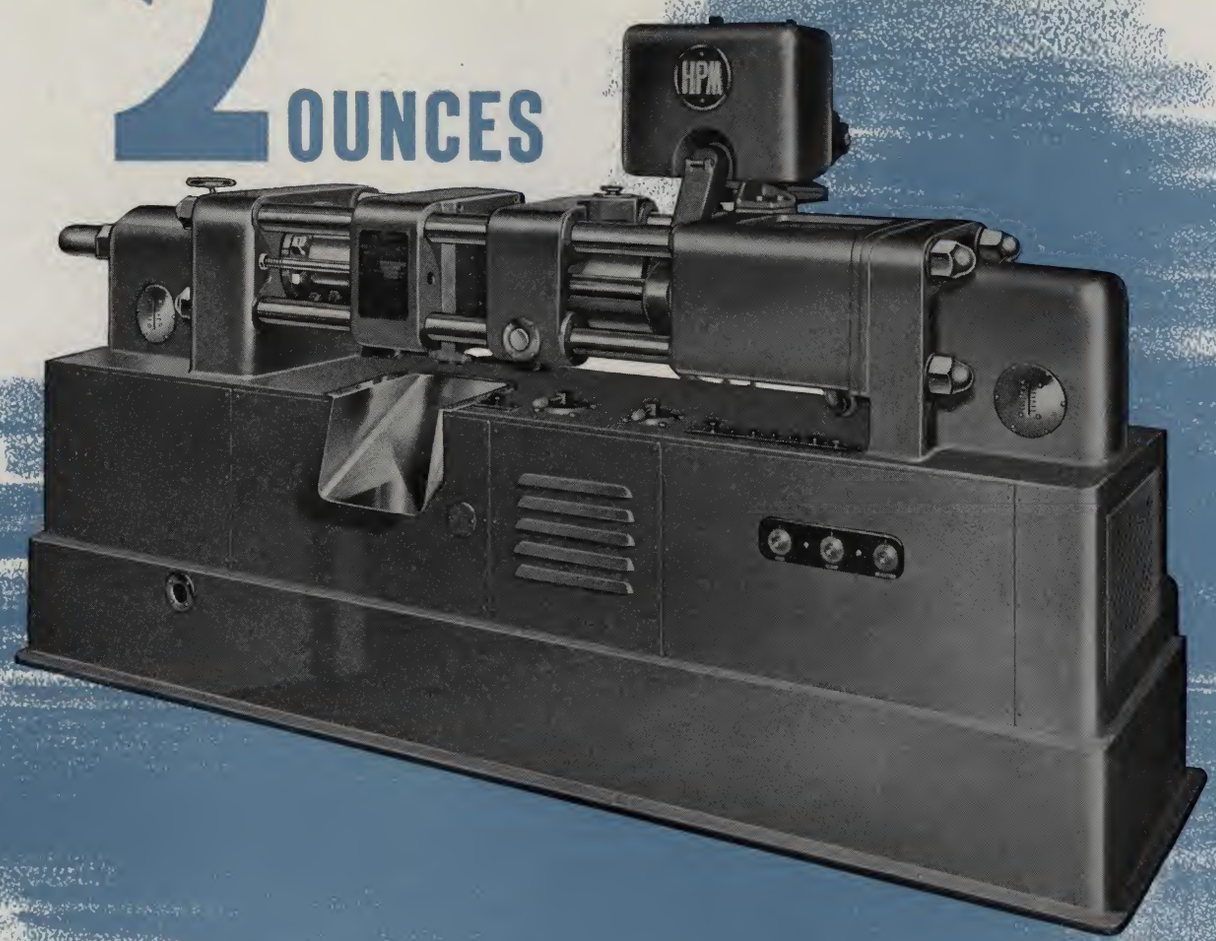


Figure 5273

MODEL 40-H-2

H-P-M PLASTIC INJECTION MOLDING PRESS CAPACITIES

The Model 40-H-2 is a complete self-contained injection molding press of the horizontal clamp type. Though the smallest machine of the complete H-P-M line, it is a most profitable volume producer of small plastic parts, capable of cycling rapidly – providing large output with economical dies. A well balanced, completely equipped plastic plant should have several machines of this size.

Clamp pressure – 40 tons.

Maximum mold size – 14½" x 16".

Minimum shut height of mold – 6".

Maximum opening between platens, open position – 18".

Maximum stroke of mold carrier platen – 12".

Maximum weight of material injected, one cycle – 2 oz.

Pressure per square inch on material in injection chamber – 16,000 pounds.

OUTSTANDING EXCLUSIVE H-P-M FEATURES

H-P-M Automatic Material Feed – Granular molding material is delivered to the injection chamber by motor driven feed.

H-P-M Straight-Line Hydraulic Clamp – provides ample force to separate mold halves and operate knockouts.

H-P-M Variable Capacity Radial Pump Hydraulic Drive – for maximum power economy and complete control.

4 OUNCES

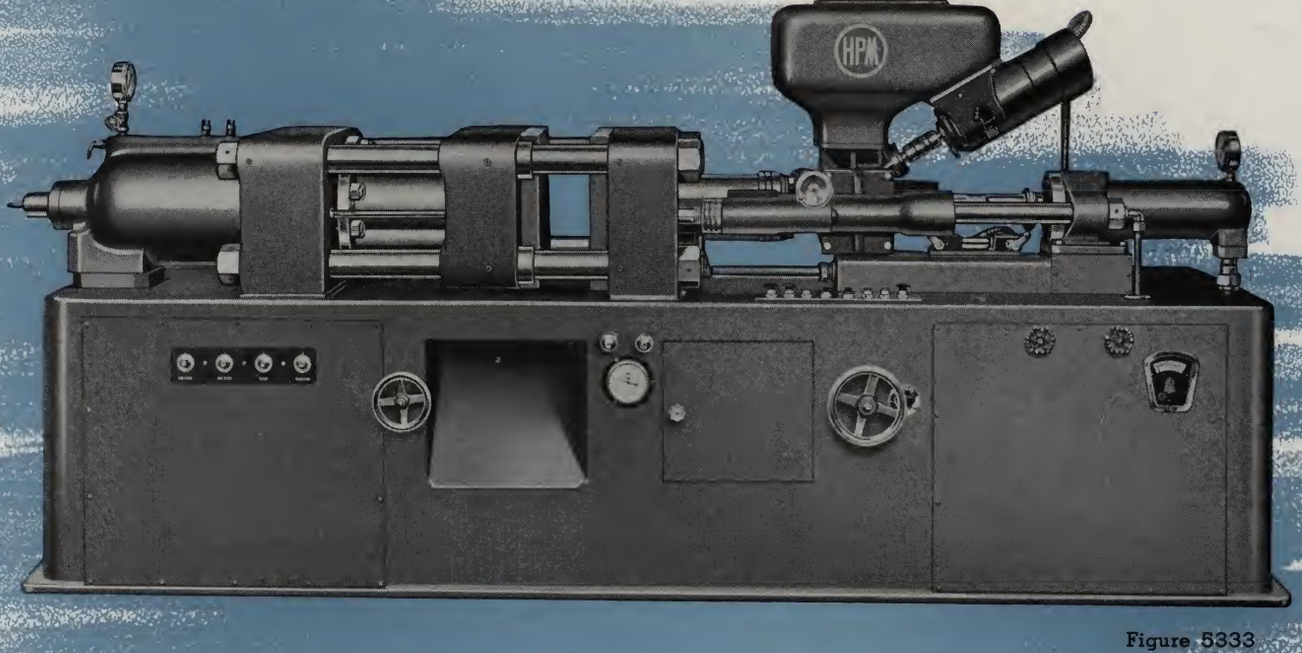


Figure 5333

MODEL 100-H-4

H-P-M PLASTIC INJECTION MOLDINC PRESS

CAPACITIES

The Model 100-H-4 is the second size Injection Molding Press in the H-P-M line. Of intermediate capacity, it is equally suitable for long run production and small job lots because in favor of the latter, molds can be changed quickly and no fine adjustments are necessary in changing from one job to another.

Clamp pressure – 100 tons.

Maximum mold size – 16½" x 24".

Minimum shut height of mold – 6".

Maximum opening between platens, open position – 18".

Maximum stroke of mold carrier platen – 12".

Maximum weight of material injected, one cycle – 4 oz.

Pressure per square inch on material in injection chamber – 20,000 pounds.

OUTSTANDING, EXCLUSIVE H-P-M FEATURES

H-P-M Straight-Line Hydraulic Clamp – does not require fine adjustment for molds of different thickness.

H-P-M Variable Capacity Radial Pump Hydraulic Drive – provides constant pressure against the clamp ram with a minimum of power consumption due to its variable volume feature.

H-P-M Circulating Fluid Heating of Injection Chamber – eliminates fluctuation of temperature at the material heating chamber. Plastics of delicate tints can be handled without burning.

9 OUNCES



Figure 5556

MODELS 200-H-9 or HX-9

H-P-M PLASTIC INJECTION MOLDING PRESSES

CAPACITIES

The Model 200-H-9 or HX-9 meets the modern demand for increased capacity in injection molding. It follows the latest design H-P-M has developed in the horizontal type with heavy clamp pressure. This size is definitely a large producer – capable of clamping and filling large mold cavities as well as multiple small cavity molds.

Clamp pressure – 200 tons.

Maximum mold size – 16½" x 24".

Minimum shut height of mold – 6".

Maximum opening between platens, open position – 18".

Maximum stroke of mold carrier platen – 12".

Maximum weight of material injected, one cycle – 9 oz.

Pressure per square inch on material in injection chamber –

200-H-9.....20,000 pounds

200-HX-9 .....30,000 pounds

OUTSTANDING, EXCLUSIVE H-P-M FEATURES

H-P-M Straight-Line Hydraulic Clamp – Fewer working parts; no links, toggles, wedges, etc., that require fine adjustments.

H-P-M Variable Capacity Radial Pump Hydraulic Drive – provides freedom from costly production delays caused by pump failures.

H-P-M Circulating Fluid Heating of Injection Chamber – is completely self-contained within the press. No electrical temperature controllers remotely mounted.

12 OUNCES

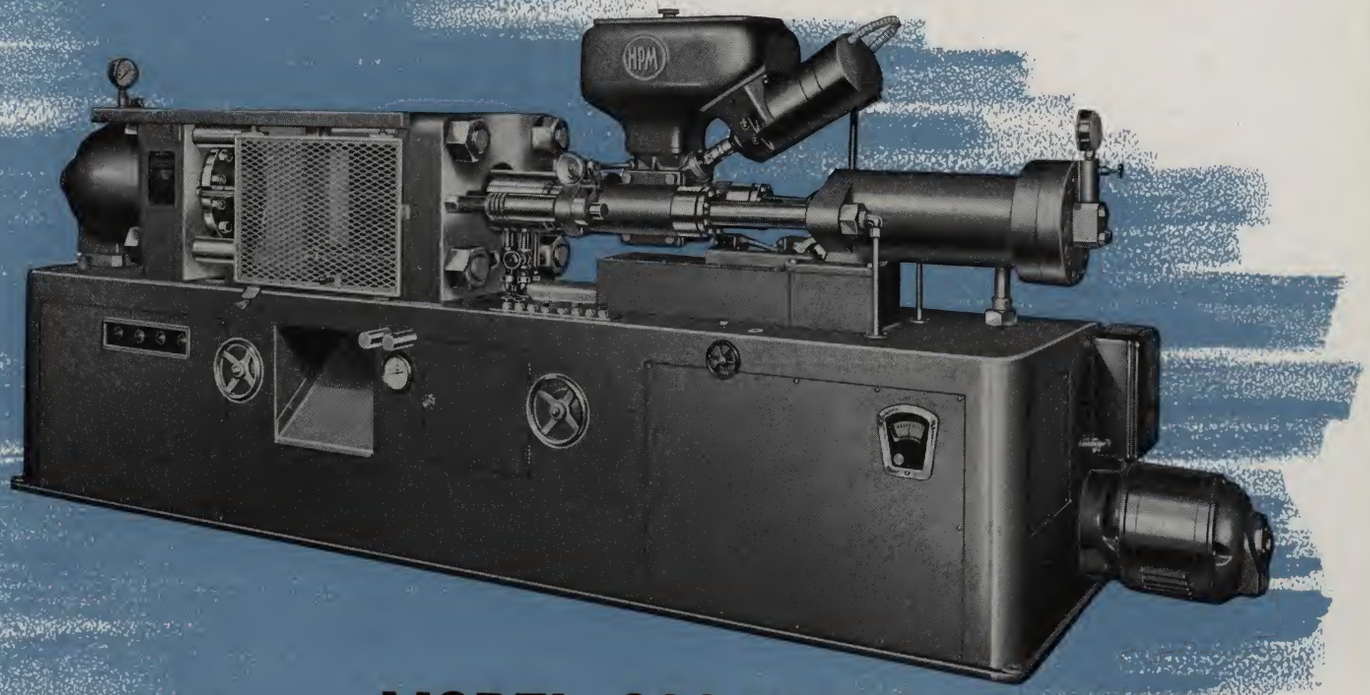


Figure 5407-A

MODEL 200-HX-12

H-P-M PLASTIC INJECTION MOLDING PRESS CAPACITIES

The H-P-M Model 200-HX-12 follows the established design of the H-P-M Horizontal Clamp Type – but with pressure on material stepped up to 30,000 pounds/square inch at increased injection plunger speeds, thus injection capacity is not sacrificed for the higher pressure. The clamp unit duplicates that of the 200-H-9 and HX-9; injection unit is especially built throughout for practical operation at increased pressure and volume. Each unit is individually operated from separate H-P-M Radial Pump Power Units. A third radial pump with driving motor provides for full injection output at increased injection plunger speed.

Clamp pressure – 200 tons.

Maximum mold size – 16½" x 24".

Minimum shut height of mold – 6".

Maximum opening between platens, open position – 18".

Maximum stroke of mold carrier platen – 12".

Maximum weight of material injected, one cycle – 12 oz.

Pressure per square inch on material in injection chamber – 30,000 pounds.

OUTSTANDING, EXCLUSIVE H-P-M FEATURES

H-P-M Straight-Line Hydraulic Clamp – clamping force definitely known and adjustable.

H-P-M Variable Capacity Radial Pump Hydraulic Drive – with automatic pump control regulating volume and pressure output according to demand with possible saving in power consumption.

H-P-M Circulating Fluid Heating of Injection Chamber – assures uniform heating and full control over the temperature of the plastic material in the injection chamber.

★ H·P·M PLASTIC INJECTION MOLDING PRESSES ★

18 and 36 OUNCES

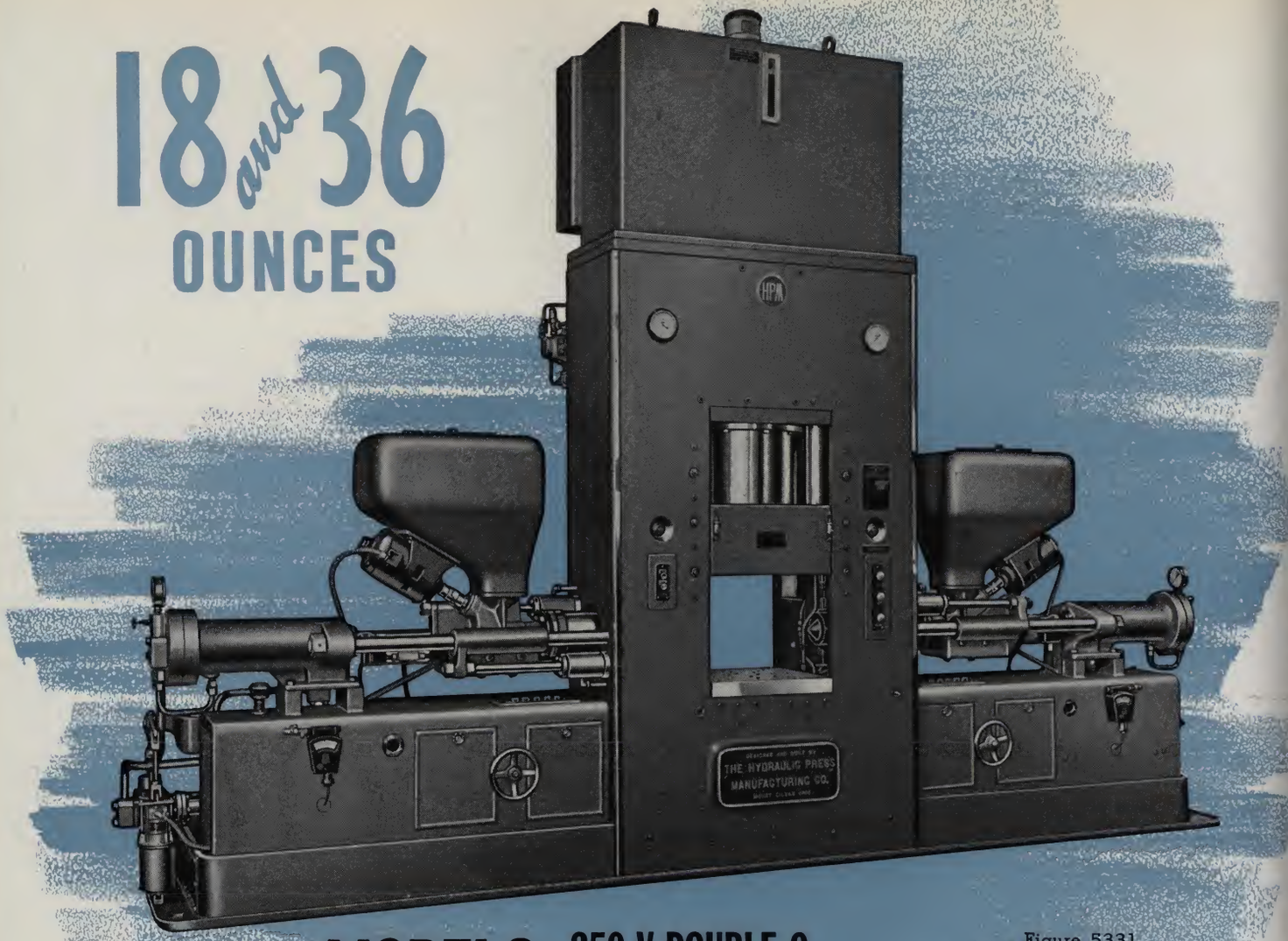


Figure 5331

MODELS 250-V-DOUBLE 9 500-V-QUADRUPLE 9

H-P-M PLASTIC INJECTION MOLDING PRESSES CAPACITIES

These large presses primarily consist of a plate frame, downward acting FASTRAVERSE press, the platen of which serves as the mold clamp. At the sides of the platen press are mounted the injection units. Each injection unit is similar to the injection unit of the 200-H-9 single nozzle horizontal clamp press. Each injection unit is timed and synchronized with the vertical downward acting mold clamp action. Press operation is semi-automatic. The Hydraulic Press Manufacturing Company is the exclusive builder of these large capacity machines.

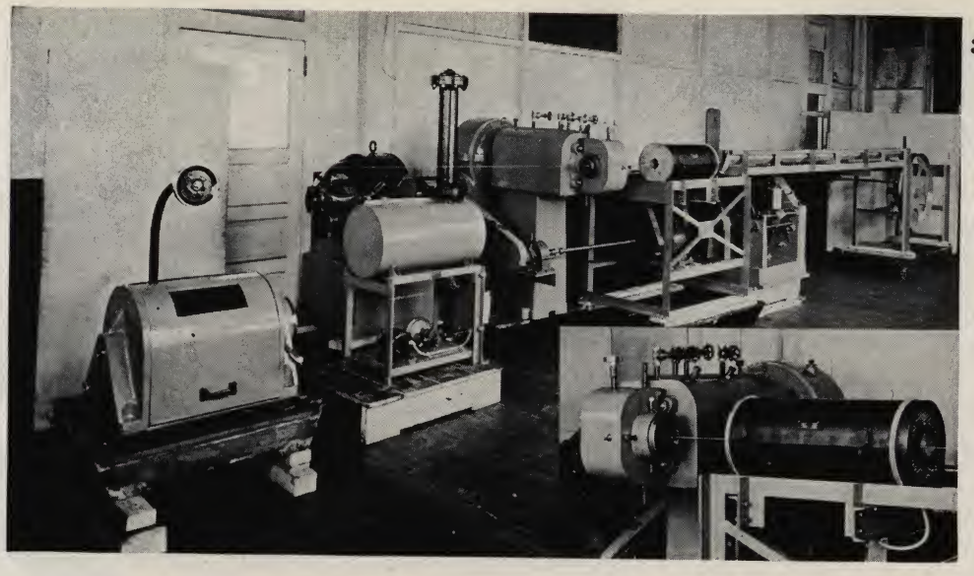
Clamp pressure (tons)	250	500
Maximum Mold Size	24"x24"	36"x48"
Minimum Shut Height of mold	14"	16"
Maximum opening between clamp platen and bolster	29"	40"
Number of injection units	2	4
Maximum weight of material injected, one cycle	18	36
Pressure per sq. in. on material in each injection chamber	20,000#	20,000#

OUTSTANDING, EXCLUSIVE H-P-M FEATURES

H-P-M Straight-Line Hydraulic Clamp – assures smooth operation with positive protection against overload.

H-P-M Variable Capacity Radial Pump Hydraulic Drive – tapered roller bearings separate vital working pump parts. External adjustment for "taking up" bearing wear can be accomplished without dismantling the pump. These exclusive H-P-M radial pump features assure maximum pump efficiency over a long period of time.

H-P-M Circulating Fluid Heating of Injection Chamber – temperature in the injection chamber is stabilized by this method through the equalizing effect of a volume of liquid.



3

3—Complete layout of resin wire insulating equipment. Wire passes from bare wire reel, through insulating machine head, high annealing furnace, water-cooling spray trough, wiper pad, and around drawing capstan to take-up reels. Inset shows closeup of extruder and the annealing furnace

place, we have a T-shaped unit, the extruding machine being the stem of the T and the cross-head, attached to the machine at right angles to the screw, being the bar. The form to be covered is introduced through a guide at one end of the head and, as it is drawn through, the extruder applies a plastic coating the shape of the die at the exit end of the head.

Thermoplastic materials have been successfully extruded on machines essentially the same as those used for rubber. But the day of improvisation is past and efficient production of extruded plastics requires specialized machinery, critical control of operating conditions and patient, meticulous application to development work with each new material and product. However, since there exists a general knowledge of the use of the extruding machine for working rubber, this article will utilize such as a point of departure or to draw parallels.

Temperature is important in working rubber, but critical in extruding plastics. Extruding machine cylinders, heads and dies are cored and feed screws are hollowed and fitted with circulating pipes—all for the introduction of steam, water, oil or other heat-and-cold transfer media.

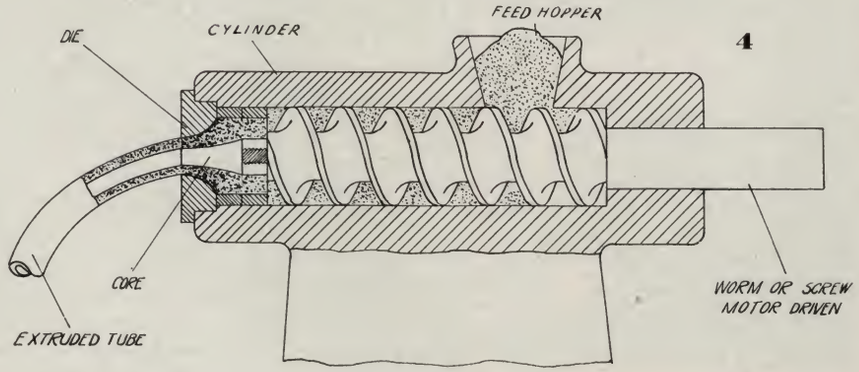
For rubber, a machine is normally warmed up previous to first feeding and then, except for the die section, cooled with water as frictional heat is generated. While extruded rubber forms are later cured at high temperature, rarely does rubber extrusion require temperatures in excess of 212 deg. F. and then for short pre-feeding periods.

The adaptation of the extruding machine to plastics required the redesigning of the machine to safely carry controlled temperatures of from 212 deg F. to 450 deg. F. In addition, since longer exposure to heat is required, the cylinder and screw of the plastics machine are longer, offering about twice the heating surface as in a rubber unit. Each plastic compound has its own peculiar reaction to heat, so variations in control of the separate circulating passages are provided, such as separate valves for each section or individual sources of temperature-regulating media.

In addition to redesigning rubber machines for the use of higher temperatures encountered in the plastics field it has been necessary to incorporate additional safety factors to withstand the tremendous pressures developed forward in the head section and in the rearward thrust of the feed screw.

The ideally designed and assembled machine is, interiorly at least, a toolroom-precision job. Continuous flow of plastic is provided for, with screw, cylinder, head and die surfaces having no pockets or joints where the plastic may lodge and become overheated or make cleaning difficult. Dies and associated head fixtures may well be plated with chromium or like material to a depth of .004 in. and highly polished to eliminate tool marks and present a non-dragging surface.

In some cases, unless the plastic material is particularly heat-sensitive, a strainer or breaker plate is introduced between the die and the end of the screw.



4

4—Drawing which shows in detail the operating mechanism of a screw type extruding machine. While this represents the essentials, variations on production machines are required depending on materials used and capacities

The vagaries of cellulose nitrate are peculiar to that material, requiring complete absence of frictional heat and to that end a supplementary speed reduction unit is employed so that screw speeds in the vicinity of 40 rpm are available.

Since some plastics set up chemical reaction with the metals in which they come in contact, attention is given the choice of materials of which the cylinder liner and feed screw are made. Too, the abrasive characteristics of some plastics necessitate use of an exceptionally wear-resistant material for these parts.

As has been stated previously on these pages, it is practically impossible to describe all the conditions necessary to the proper extrusion of plastics. It would be untrue to infer that purchase of an extruding machine with the above-mentioned design features places the purchaser in position for immediate profitable production of extruded plastics. It is only fair to include in this discussion some mention of important details, supplementary fixtures and accessory equipment necessary to the efficient conversion of plastic raw materials into usable extruded sections.

Feed screw design, long a topic for discussion in the extrusion of rubber compounds, becomes quite involved in the plastics field. All through the extrusion process, some thermoplastics require a special, individual technique, and screw design research is an important item in the development work necessary. Variations in screw design cover length, number and pitch of threads and depth of flutes as well as choice of materials. Extruding machine manufacturers and plastics fabricators should be prepared to compare notes and together decide the course to be followed in making screw specifications compatible with the known characteristics of the material.

5—Oil-heating and circulating system for use on extrusion machines. Other circulating media may also be used for heat transfer and may be adapted for heating units other than extrusion

5



Some plastics adapt themselves well to screw feeding, while others clog the feed throat immediately or regurgitate into the feed opening. Therefore, the use of supplementary feeding mechanisms is usually advisable. Such a feeder may take the form of a cascade or vibrating hopper. Since thorough pre-drying of the material is necessary not only for efficient feeding but to eliminate possibility of blistering or roughness in the finished product, such drying may be done in conjunction with the feeding process.

In the rubber factory, the extruding machine is piped to standard plant steam and water lines. However, the plastics manufacturer utilizes a thermostatically regulated heating and circulating system for forcing oil, Dowtherm or other heat-transfer medium through his extruding machine.

Normally, the extruded product issues from the die in a more or less hot, soft form easily deformed. Hence, provision must be made for its reception, removal and cooling so that there will be no deformation. In many cases the plastic may be received and air-cooled on an endless rubber-covered or metal belt or allowed to slide down an inclined chute by gravity. In others, the product must be drawn through a coolant or floated thereon—depending on a jet (or jets) of coolant or a conveyor or draw rolls beyond the coolant for uniform removal speed. Wire, or course, must first be cooled and then wound on a reel, with the peripheral speed of the reel timed to the take-off and cooling device.

There is always a short space through which the product cannot be supported after issue from the die. Hence, proper relation of die to conveyor is necessary so as not to deform the strip produced. If the die be revolved 90 or 180 deg., in many cases a surface will be found that will contact the draw-off belt more advantageously than others.

Developments are being made every day in advancing the design of extruding machines and accessories to meet the rapid increase in the use of the extrusion process in the plastics industry. Close cooperation among manufacturers, raw material suppliers and fabricators is making possible the availability of extruding machines adaptable in size and other respects to the production of an increasingly wide range of products.

While the art of extrusion isn't new it is only within comparatively recent date that many of its potentialities have begun to be explored. Originally perhaps the largest production from these machines went into the novelty field. They were rods and other profiles made from nitro-cellulose. They were wet processed. Later the machines were used for wire coating or insulating. Here vinyl derivatives have been applied. With extruding from dry powder having been reasonably perfected renewed widespread interest arrived. Today in automobiles extruded forms serve for decorative trim. They are used as band separators on radio dials; other profiles from various materials are found in fishing lines and woven into attractive patterns for furniture. Many other applications in the housing and decorative fields are on the threshold of production.

WHEN YOU IMPROVE YOUR PRODUCT WITH SELF-TAPPING SCREWS . . .

Specify PARKER-KALON

Avoid *"Doubtful Screws"* and make certain of getting better fastenings at lower cost



TYPE "Z"

. . . the all-purpose Self-tapping Screw. Forms its own thread in the material. Recommended for making fastenings to cellulose acetate and nitrate compounds, methyl-methacrylate resins, polystyrenes, and laminated phenolics. May be driven with any type of driver. Can be removed and replaced repeatedly.

TYPE "F"

. . . expressly developed for use in crumbly and friable materials, such as phenolic and urea base compounds, cold mold compositions, and hard rubber. Cuts a thread like a tap. May be driven with any type of driver. Can be removed and replaced repeatedly.

TYPE "U"

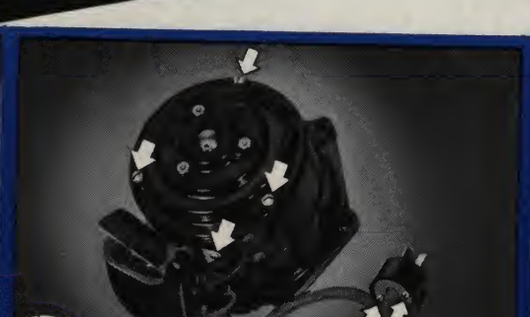
. . . for making permanent fastenings only, to all kinds of plastics. Hammered in or otherwise forced into the material. Cannot be removed.

Thousands of manufacturers know that Self-tapping Screws offer the easiest, quickest and most economical means of assembling plastics of every nature. But they know, too, that the full benefits which Self-tapping Screws bring, can only be attained with a trouble-free product.

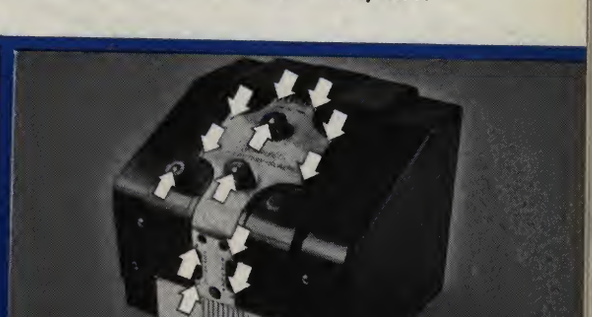
It is not strange, then, that most users take no chances on "Doubtful Screws"—screws that may look satisfactory but of which a percentage fail to perform properly . . . running up costs by slowing down production and causing spoilage of parts. These manufacturers insist on genuine Parker-Kalon Screws . . . *quality-controlled* to highest standards by the famous Parker-Kalon Laboratory. Let us send you Free Samples for experiment . . . see for yourself.

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Hart Mfg. Co. ended difficulties of tapping small holes by using four Type "F" Screws for attaching cover plate to a phenolic switch case.

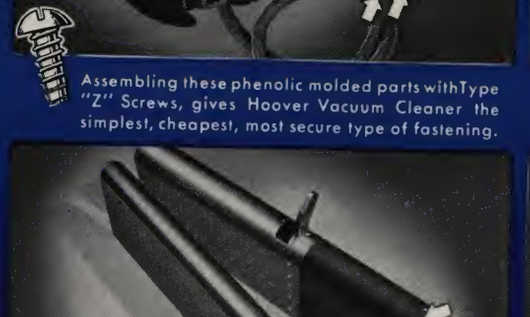


Assembling these phenolic molded parts with Type "Z" Screws, gives Hoover Vacuum Cleaner the simplest, cheapest, most secure type of fastening.



The time-and-labor-saving advantages of Type "U" Screws helped the Wappler Co. produce a low priced, efficient cautery with a wide market.

For attaching metal case and top to a friable plastic case, the New Haven Clock Co. cut assembly costs by using Type "F" Screws.



Glenn L. Martin, aircraft makers, save labor and increase structural strength by using Type "U" Drive Screws for assembling unique laminated phenolic fabric trim tabs.

***Free* ENGINEERING SERVICE**

To assist manufacturers in obtaining better fastenings at lower cost, Parker-Kalon maintains a staff of assembly engineers throughout the country. Their services are free to users of Parker-Kalon Products and to those seeking time-and-labor-saving fastening methods. It will pay you to avail yourself of this service. Write: Parker-Kalon Corporation, 192-198 Varick Street, New York.

PARKER-KALON *Hardened* SELF-TAPPING SCREWS

A TYPE AND SIZE FOR ASSEMBLING PLASTICS OF EVERY NATURE

Assembly Devices

MOST big and little industries have a department known as the assembly line, or assembly division. Toward this area there is a constant flow of component parts that are quickly and accurately put together to form complete units. One of the most important sections of any industry, this matter of assembly has attracted some of the best engineering ingenuity in recent years, with the result that a great many assembly devices and systems have been created and made available for specialized manufacture.

From the assembly line the various products go on to other departments that finish, inspect and pack for shipment into a competitive world. Very often the ultimate service that the merchandise will give depends upon how well the pieces are put together.

Serious attention has been given to economy in assembling manufactured parts. Inserts and fastening devices are designed to require the minimum of time and effort to put them in place. But, once they are in place, they have been engineered to perform their fastening service with no sacrifice in efficiency.

Few of these devices have been designed exclusively for plastics but ever since plastic products have been molded in more than one piece, manufacturers have required a successful method of fastening them together. Since most of them are molded in more than one piece, any manufacturer using plastic parts, either as complete units or as accessories, will find it to his advantage to examine the merits of the various assembly devices and choose the ones best suited to the particular job he has in mind.

The physical properties of the particular type of plastic material used should be considered, and stresses and strains likely to be set up in using the part should be carefully estimated in order to avoid failure of the part in use. Most plastics are capable of supporting inserts which may be molded in or driven in place after the piece is taken from the mold.



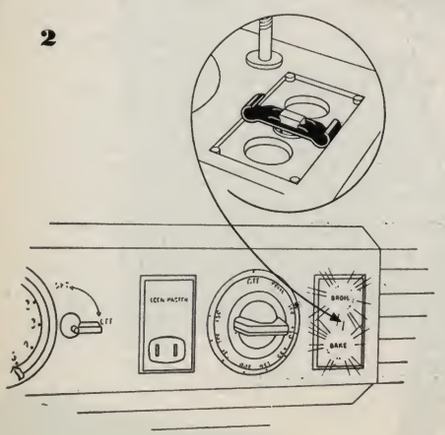
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Inserts

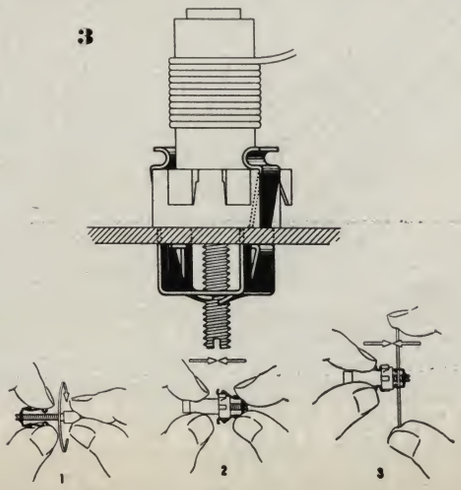
There are a number of reasons why inserts are used and almost any mold requires its own particular design. Sometimes they are used with bosses. At other times, they are allowed to project so that plates may be located properly for rapid assembly. There are times when the

1—A wide assortment of typical metal parts used in many plastic parts. Included are a bar bin, desk set funnel holder, smoking pipe parts, wire hook, parts for comb, brush and mirror set and a knurled steel pin. Inserts are by Publix Metal Goods Corp. 2—An electric range has a plastic take-out plate serving as lens for pilot light. A Speed Nut with 2 spring arms fastens to the integral plastic stud holding the assembly in place, yet permitting easy removal for replacement of light bulbs. 3—In this radio coil form assembly one Speed Nut does three jobs. It fastens adjustment screw and core to coil, provides a frictional tension for core screw adjustment and secures entire assembly. The three assembly stages are shown below. 4—For assembly of plastic moldings and trim strips, Speed Clips are locked into holes in steel panels, the molding is then snapped over the spring arms of the clip. (All by Tinnerman Products, Inc.)

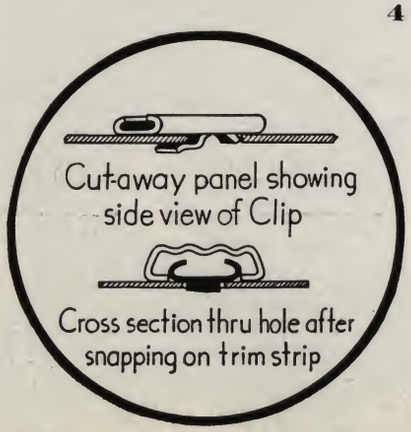
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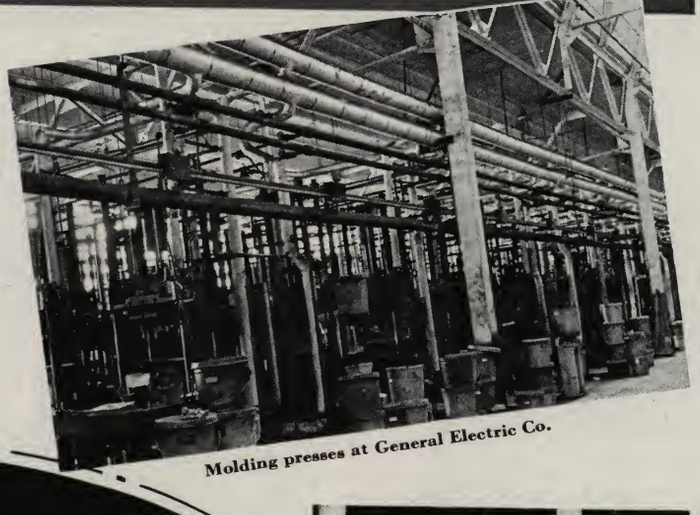


4



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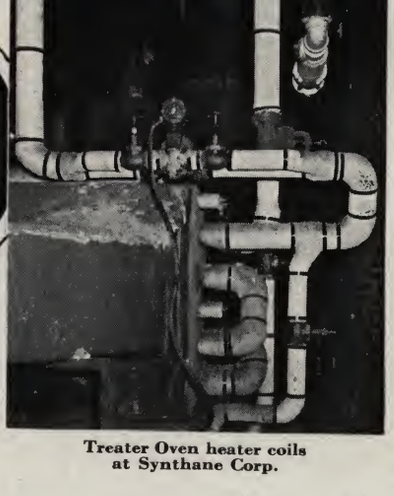
Molding presses at General Electric Co.

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Treater Oven heater coils at Synthane Corp.

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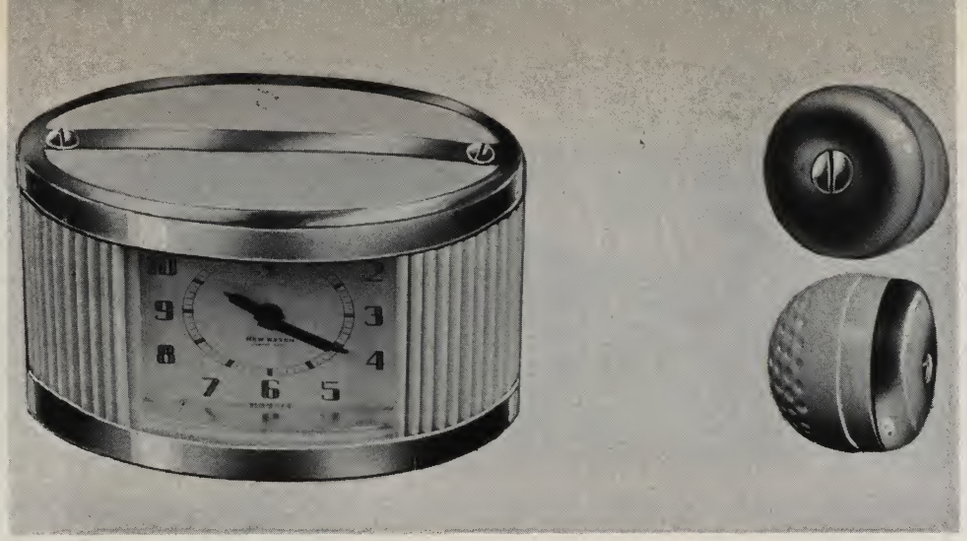
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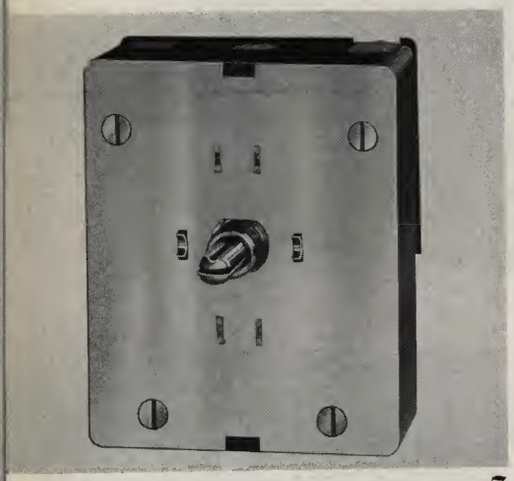
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12953 Greeley Avenue, DETROIT



5



6



7

5—This type hardened self-tapping screw by Parker-Kalon Corp. is used to attach top and bottom metal stampings (6) to this molded travel clock case. 7—Cover plate of a multipole switch is firmly secured to plastic base by 4 similar self-tapping screws

molded part is of such design that it is difficult to mold inserts in, so a hole which is somewhat smaller than the insert is molded in the piece. Then, while it is still hot, the insert is pressed in and the compound shrinks around it. Molding inserts in place is cheaper, of course, when it is practical to do so.

When they are to be molded in, inserts are placed on pins built into the mold and the compound flows around them when the press is closed. Inserts are most commonly used in compression and transfer molding. Since the flow action of the plasticized material is more gentle in transfer molding, this method should be employed where delicate or complicated inserts are required because they are less likely to be displaced or damaged. Glass disks, or dials, are frequently molded in bezels by this method.

There is a limit to the size of inserts which can be safely placed in molding compound. Sufficient wall thickness must be maintained around the insert to prevent cracking when the material shrinks in cooling. In other words, there must be sufficient thickness to the molded part to absorb the shrinkage without letting go. Large inserts should be heated before they are placed in the mold.

Plate inserts made from sheet stock are frequently used in electrical parts. They have shafts which anchor them into the compound. They give a metal base or plate to work on instead of plastic.

Speed nuts and clips

Common screws have been largely displaced by improved variations which speed up assembly and perform economical service for individual applications. Some are made with special studs which project so that a speed nut can be slipped in place to anchor the part.

Speed nuts are used a great deal on radio and automotive assembly, especially in hard-to-reach places. Originally developed to fasten handles on stoves, there are a number of types now in use, each developed for a particular job. Some of them may be removed as quickly as they are put in place where adjustments or repairs are likely to occur. Others are designed for permanent fastenings and are difficult to remove.

A fastening device, called a speed clip, has been developed to fasten plastic parts to metal without the need of gaining access to the opposite side of the assembly. In many cases it also avoids the need of threaded inserts. The device itself is a tubular-like formation of spring steel. While being quite cylindrical in shape, it is not a complete cylinder. The end of the speed clip enters the opening, is curled-in, while the other end is flanged outward. In this entering position, the tongues on either side are compressed into the body of the clip. With the clip fully inserted, two cam-like tongues spring out and lock the clip firmly in the hole. The flanged end prevents the clip from completely passing through the hole. However, in this position the clip is not yet fully expanded, as the end of the stud has just approached the further end of the clip. But when the stud is pushed completely *home*, the clip is fully expanded and the curled-in end of the clip bites into the stud to lock it securely. This assembly method is said to be adaptable to most any part such as name plates, trim strips, medallions and the like. There is, therefore, what may be termed a double locking device. It is an assembly device which first locks itself firmly in place and also firmly locks the stud of the name plate in assembled position.

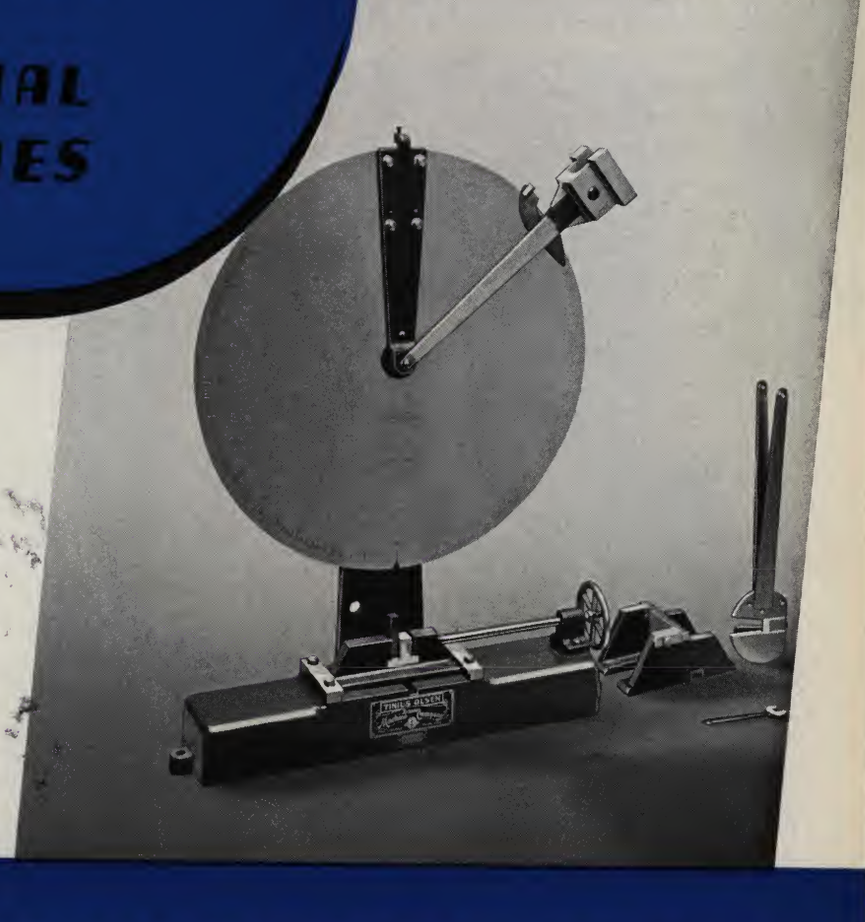
With slight variations in design this clip may be used as a permanent lock, a removable lock or as a slideable grip type. The permanent locking type is best suited to assemblies that must endure much vibration and where removal is seldom necessary. The second, or removable locking type, is best adaptable to assemblies that may



THE OLSEN-BAKELITE FLOW TESTER
For determining the flow relations of Thermo-Setting and Thermo-Plastic materials.

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Modern Machines for Testing Modern Materials

Our long experience in the study and solution of Materials Testing problems is built in Olsen's Modern Testing Machines.

Olsen Universal Machines are simple in construction, parts are few and accessible. Inertia and lag are inherently low in the Mechanical Type Pendulum Weighing System.

The machines here illustrated and others for making Tension, Compression, Flexure, Distortion, and Stiffness tests of Plastic Materials are illustrated in our Bulletin No. 17 which will be forwarded upon request.

THE OLSEN IMPACT TESTER
For measuring resistance to shock.

TINIUS OLSEN TESTING MACHINE COMPANY

1004 BUTTONWOOD STREET . PHILADELPHIA, PA. U. S. A.

require an occasional separation of the parts. By predetermining the amount of "pull" desired for removal, the curled-in end of the clip is formed with the correct degree of *bite*. The slideable grip type is recommended by the manufacturer where studs are made of relatively soft plastic materials such as cellulose acetates.

This speed clip assembly device is unique in that it eliminates the use of wrenches, pliers or screw drivers in assembling. The entire assembly work is reduced to the simple and rapid insertion of these clips into holes and the studs into the clips.

Speed clips and speed rings are provided for attaching round knobs and similar parts and are so shaped that the harder you turn the knob, the tighter they grip. Yet, they may be quickly removed and used again should the part require adjustment or renewal. While speed nuts and speed clips provide a means of rapid assembly, they should be concealed inside the piece because they do not present a finished appearance.

One manufacturer makes elastic stop, self-locking nuts that have a tough but resilient locking collar, made of a bone-like cotton cellulose fiber, chemically hardened. This material is not affected by immersion in oil, water, or ordinary solvents. The collar is not threaded. When applied to a bolt, these nuts act in every way as an ordinary nut until the locking collar reaches the end of the bolt. When the nut reaches this point, the collar presses against the end of the bolt, and the nut is forced outward, its outer thread flanks being brought into pressure-contact with the inner thread flanks of the bolt. Immediately and automatically, all thread play is eliminated and friction is established between the threads of nut and bolt throughout the entire length. As the nut is wrenched farther, the bolt threads work their way through the unthreaded locking collar. They do not cut the fiber but impress a thread into it. This creates a moisture-tight seal around the bolt and provides additional braking effect to resist any turning of the nut. The nuts can be removed and used over again, since they always retain their full locking effectiveness.

Self-tapping and metallic drive screws

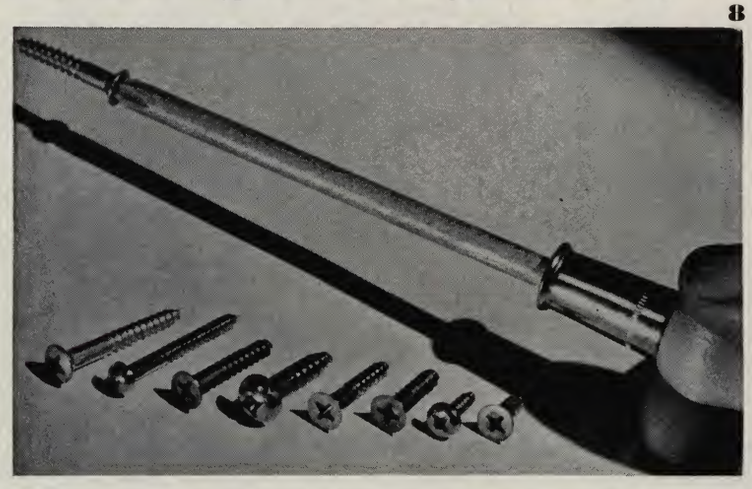
Hardened metallic drive screws are used for making permanent fastenings only. They are driven in with a hammer or may be pressed into holes drilled or molded in the material. As they cannot readily be removed, they are recommended only for the assembly of parts that do not have to be disassembled after completion for servicing or repair.

Hardened self-tapping screws are available in two types for making fastenings to plastics of every kind. One type forms its own thread by extruding the plastic. The other cuts its thread by removing the material like a tap. The first kind is recommended by the manufacturer for making fastenings to all types of plastics where the area immediately surrounding the hole has sufficient mass to absorb compression incident to the formation of the threads. These screws find their greatest usefulness in plastics which include cellulose acetate and nitrate compounds, certain types of phenolics and cold-molded compositions.

The second type has tap-like characteristics and is particularly suited for plastics of a crumbly or granular nature since little, if any, strain is transmitted to the material adjacent to the hole during the driving operation. The tap-fluted pilot makes this screw capable of cutting a thread in the material as it is turned in. The screw thread is so designed that, if necessary, a standard

8—These patented Phillips cross-slot screws are designed to cling to the driver tool, facilitating assembling, as operators need use one hand only. 9—Methyl methacrylate table assembly with Phillips recessed head screws. 10—Shakeproof Lock Washer Co. manufactures these various types of thread-cutting and thread-forming screws for plastics and metals

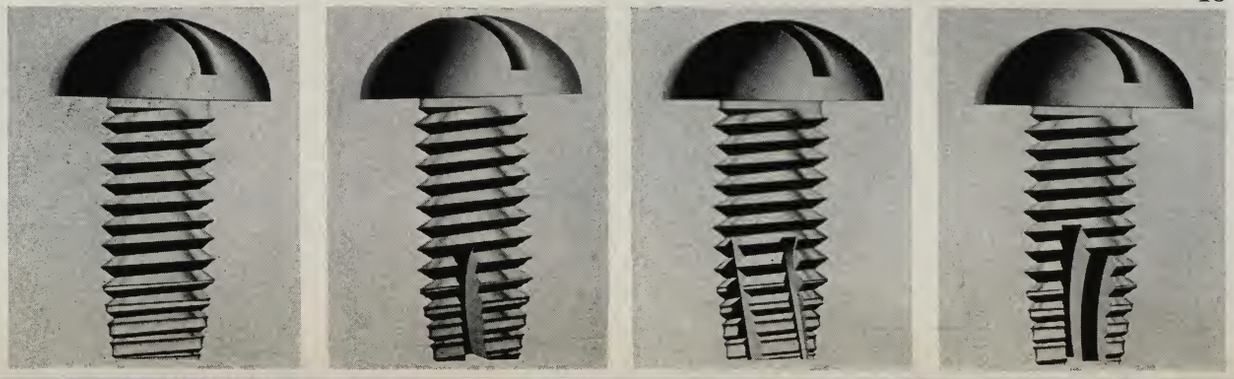
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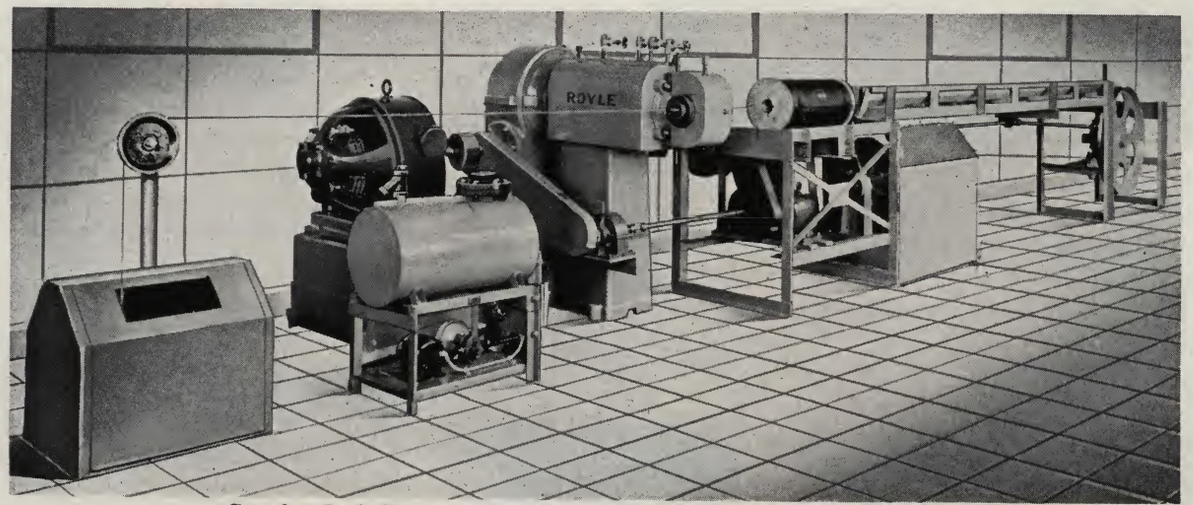


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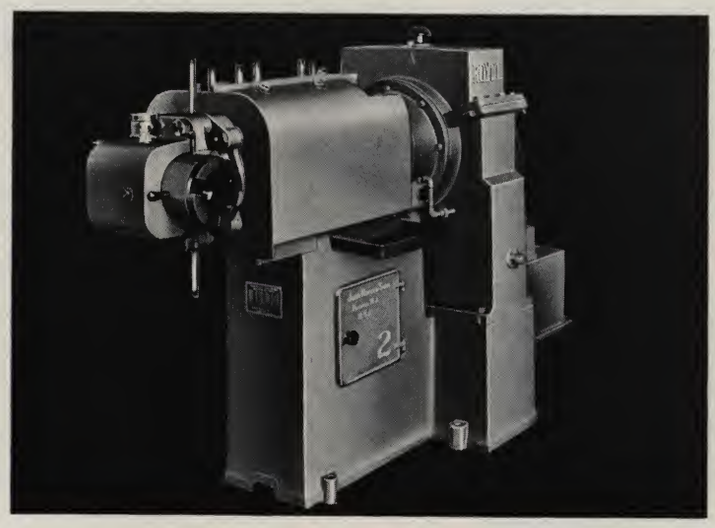


EXTRUDING MACHINES

for the Plastics Industry . . .



Complete Royle Equipment for Insulating Wire & Cable with Plastic Coating



No. 2 (3¼-inch cylinder diameter)
Royle Extruding Machine for Plastics Extrusion



Royle Heating & Circulating Unit for Heat-Transfer Control

Royle Extruding Machines have been in use in the processing of plastics since the invention of the screw-type machine by Vernon Royle in 1880. Our eighty-five years' experience in machine building, together with an intimate knowledge of the extruding machines we pioneered, place this company in a position to supply efficient machinery for fabricating plastics by extrusion.

We invite plastics manufacturers with extrusion problems to make full use of our engineering experience and manufacturing skill gained in filling the extrusion needs of American industry.

JOHN ROYLE & SONS

336 ESSEX STREET PATERSON, N. J.



11

11—Suspended urea lamp reflector is assembled with a sturdy bead chain. Photo, courtesy Bead Chain Co. These metal chains are available in several sizes and can be attached in novel assembly arrangements

machine screw of corresponding size can be turned into the thread formed in the material by the screw. It can also be used with a standard nut where an auxiliary fastening is required.

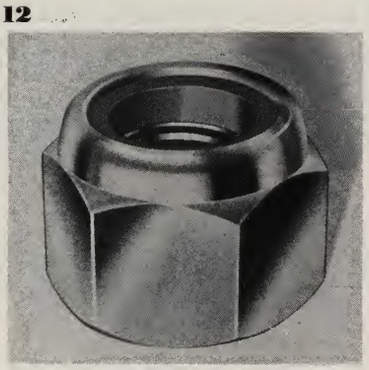
Both types are simply and easily applied, a hole of suitable size is provided in the parts to be assembled and the screws are turned in with manually operated or power driven driving equipment.

Cross slot screws

Another patented screw, with either machine screw threads or self-tapping threads, is distinguished by a recessed head and an X-slot so designed that it clings to the special screwdriver provided, and is easily started in hard-to-reach places. The double slot makes it possible to set up the screw much tighter with a minimum of effort. Either hand or power equipment can be used.

An additional advantage is reported by users of this double slot screw in that its shape allows a mere quarter turn to align properly with other screws for the sake of appearance. There are many reports of substantial savings in assembly through the use of these recessed head screws because the screwdriver "nests" securely in the double slots without any special effort of the operator to keep it in position.

12



12—Self-locking nut by Elastic Stop Nut Corp. has a resilient non-metallic locking collar for rapid, secure assembly

Aero-thread screws

The aero-thread screw features the use of a spirally wound insert or bushing of precision-formed bronze spring wire in which hardness, strength, surface smoothness and anti-frictional qualities are carefully controlled. The insert is screwed into a tapped hole and forms the seat for the screw, protecting the threads from wear and resulting in a strong thread with a hard, smooth surface against which the screw fits.

As indicated by its name, this device first found application in the aircraft industry where high-strength studs and cap screws are required but because of its high strength and great shock resistance, the screw is attractive for use in plastics assembly where compactness and lightweight are desirable.

Shakeproof screws

Another successful fastening device quite commonly used is called a shakeproof screw. There is a groove cut into the screw itself which converts the screw into a tap. As it enters the material, the screw cuts its own clean sharp thread as it turns. Another device, by the same manufacturer, provides a washer as an integral part of the screw so that none can be driven without a lock washer under the head to protect it from vibration—and no time is consumed by picking up separate washers and putting them in place.

Metal bead chain

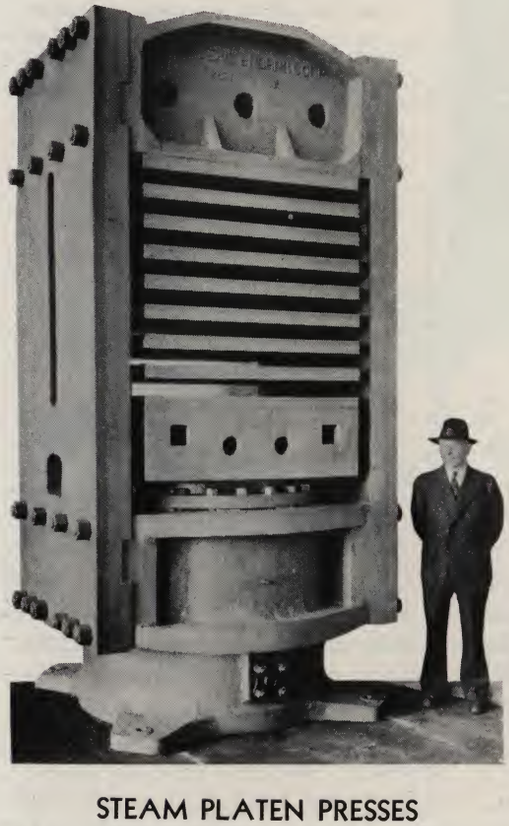
Practically all of present-day electric light sockets are equipped with metal chain pulls that are usually inserted into a molded or drilled hole in the finished plastic piece. This same type of chain may also be cemented or riveted into other plastic parts where it serves a definite purpose. These glistening bead-like chains will not kink nor tangle. Made in various metals including Monel, in sizes from $^3/_{32}$ in. to $^3/_8$ in. diameter beads, they may be used for many plastic applications in ingenious ways, such as holding suspended light fixtures attaching pencils to telephone dials, fastening unmovable parts, etc. Since the chain is light in weight and flexible as well as neat in appearance, it makes a decorative and useful assembly means, to fit many different products.

Spline lock

One of the most recent fastening devices to make its appearance is the spline lock which consists of two keys or splines which fit into slots cut into the parts to be fastened together. These slots are cut at opposing angles and, when joined together by splines, form a tight and lasting fit. If the splines are not cemented in place, the parts may be quickly taken apart if desired.

There are many obvious applications for the spline lock in furniture, radios, aircraft and automotive manufacture but its introduction is too recent to predict its status in the plastics field. Perhaps this will provide the solution for architectural problems of sheet installation.

LAKE ERIE *Hydraulic* MOLDING PRESSES

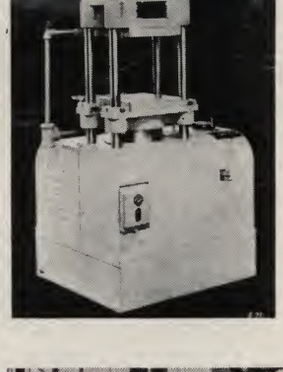


Built By One of America's Largest Hydraulic Press Manufacturers

Used By Leading Molders for Economical Production

Half a century of Lake Erie Engineering experience is responsible for the design and reliable performance which assures economy, satisfaction and low cost production in leading molding plants.

Wide Range of Sizes and Types . . . .



Plastic molders are taking advantage of the complete Lake Erie line of presses for fast economical production of widely varying sizes, shapes, and types ranging from laminated sheets to intricate one-piece finished products.

You are invited to "put it up to Lake Erie." An outline of your requirements will receive expert attention.

STEAM PLATEN PRESSES

Single opening, hand mold presses, and multiple opening steam platen presses in all tonnages. Either column design or side plate design as shown above, accumulator operated or self-contained pumping units.

← LABORATORY PRESSES

New modern lines of Laboratory Presses with compact, self-contained units including sensitive pressure and speed controls, shown at left.



6-IN-1 HIGH PRODUCTION MOLDING PRESS

Accumulator operated or with one common self-contained pumping unit with individual pressure and operating controls. A 6-in-1 unit for one-man operation. Also available in four column and multiple opening designs.

The Complete Lake Erie Line Also Includes—

SEMI-AUTOMATIC MOLDING PRESSES

16 standard sizes in either 4 column or latest side plate designs—self-contained units or accumulator operated presses—spring or hydraulic strippers.

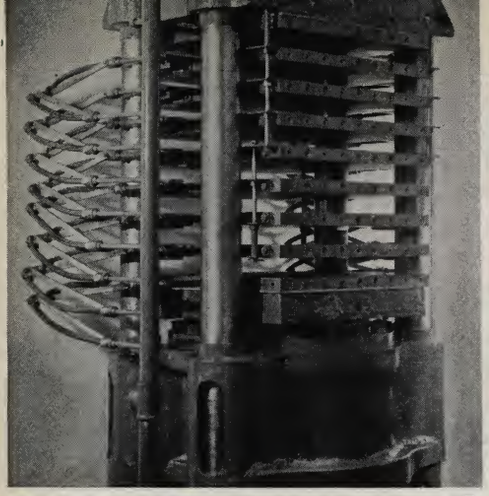
FULLY AUTOMATIC TILTING PLATEN PRESSES

Self-contained or for accumulator operation—capacities from 500 to 1000 tons—permanently rigid side plate design—entire action controlled by ram travel without separate tilting or ejecting cylinders—automatic strippers in bottom platen.

You are invited to "put it up to Lake Erie" and benefit from the wide and diversified experience of our engineers in designing, building and applying hydraulic presses for production of plastic products. An outline of your requirements will receive expert attention.

LAKE ERIE ENGINEERING CORP.

868 KENMORE STATION BUFFALO, N. Y.



1



2

1—Flexible tubing of the type coupled to the platens of this press is extensively used for conveying steam under pressure to moving parts. Made by American Metal Hose Branch, American Brass Co. 2—Circulating pumps and valves of Supertherm hot water heating system as installed by J. O. Ross Engineering Corporation

Plant equipment

NO consideration supersedes the importance of equipment in successful plant operation. There are many conditions involved in plant construction and arrangement. Plant capacity is a foremost consideration for this determines the layout, the size and the installation required. The class and kind of products or materials to be produced are basic factors. Raw material source must be weighed. The variables to be taken into account are practically limitless. Even with the utmost preliminary detailed engineering consideration it invariably follows that some minor corrections or changes are necessary after operations are under way.

Molding Plant Equipment

Established profitable plants are either constantly renewing their equipment or otherwise modernizing through adopting new machines or methods. They are continually surveying all developments. Through adopting this progressive system as a policy they combat obsolescence and depreciation.

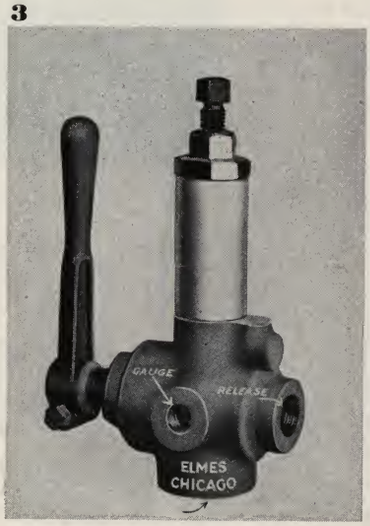
Plant equipment is obviously a broad subject, which requires thorough treatment. There are no hard and fast rules to govern either schematic layout, arrangement of machines or location of operating sections. Engineering alone must determine these plans.

Boilers

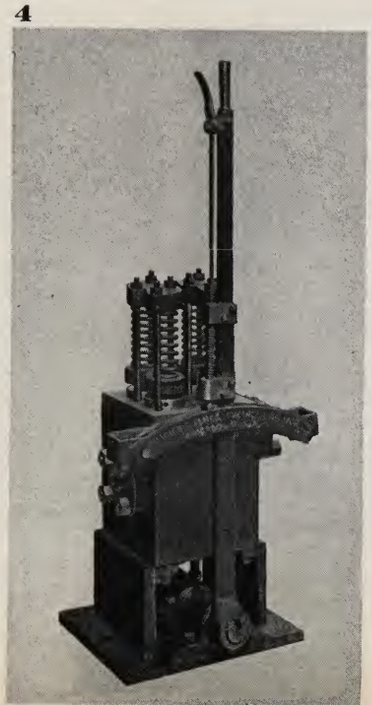
These must be of sufficient capacity to service all the the presses installed. It takes a great amount of heat and pressure to convert a cup of molding powder or a thick round pill into, say, a box or bottle cap. The heat must be intense enough (from 250 deg. to 350 deg. F. depending on the type of plastic used) to plasticize the material into a lumpless, viscous mass.

Either steam or hot water, electricity or gas may be chosen to supply this heat to press platens. Steam is probably the oldest method and the most generally used of the lot, especially in large plants where a quantity of presses are operating more or less continuously. It is generated by a centrally located boiler unit and controlled

3



4



3—Dual purpose combination release and safety valve. 4—A four way single pressure operating valve for installation on both high and low pressure systems. Made by Charles F. Elmes Engineering Works

TO THE PLASTIC INDUSTRY

LUPOMATIC Offers 30 Years of Experience and Research Work!

The LUPOMATIC organization understands every step in the manufacture of Plastic parts. Regardless of what your problem is, LUPOMATIC can be of assistance to you.

LUPOMATIC has spent 30 years in the field and whenever you run into a problem of cutting, drilling, machining or polishing Plastics, the LUPOMATIC organization is always ready to work with you.



LUPOMATIC Type S Unit Series D for Definning



LUPOMATIC Cut Off Abrasive Wheel Machine



POLISHMASTER—LUPOMATIC #40 DD Unit for Polishing

LUPOMATIC Ashing and Burnishing Mixtures—Quicklustre Creams.

LUPOMATIC compounds are specifically prepared to give the user a product which brings about a permanent and waterproof lustre. You need only use a small quantity of LUPOMATIC mixtures to produce a definite job.

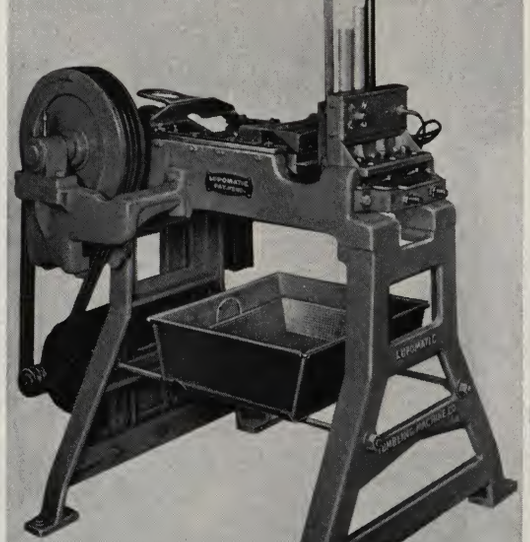
LUPOMATIC tumbling compounds are highly concentrated for very economical use.

"LUPOMATIC" TRADE MARKS REG U.S. PAT.
"QUICKLUSTRE"
"POLISHMASTER"

Trade marks covering the LUPOMATIC products. For *genuine* products, look for these trade marks.

Communicate with us and convince yourself that we can help solve your polishing and machining problems. Our service can save you time and money, and help you to produce a better job.

Write us for full information about the LUPOMATIC method for polishing and machining parts.



LUPOMATIC Wasteless Slicer



LUPOMATIC Oblique Tilting Barrel



LUPOMATIC Spindle Carving Machine

Main Office—Machine Shop and Experimental Department
4510 BULLARD AVE., N. Y. C.

LUPOMATIC TUMBLING MACHINE CO., INC.

Woodworking—Mixing and Peg Mill
LISBON, N. H.

The Mark of *Quality* in PLASTIC MOLDING EQUIPMENT

The hydraulic equipment has the severest service of any part of plastic molding equipment. It must be built right.

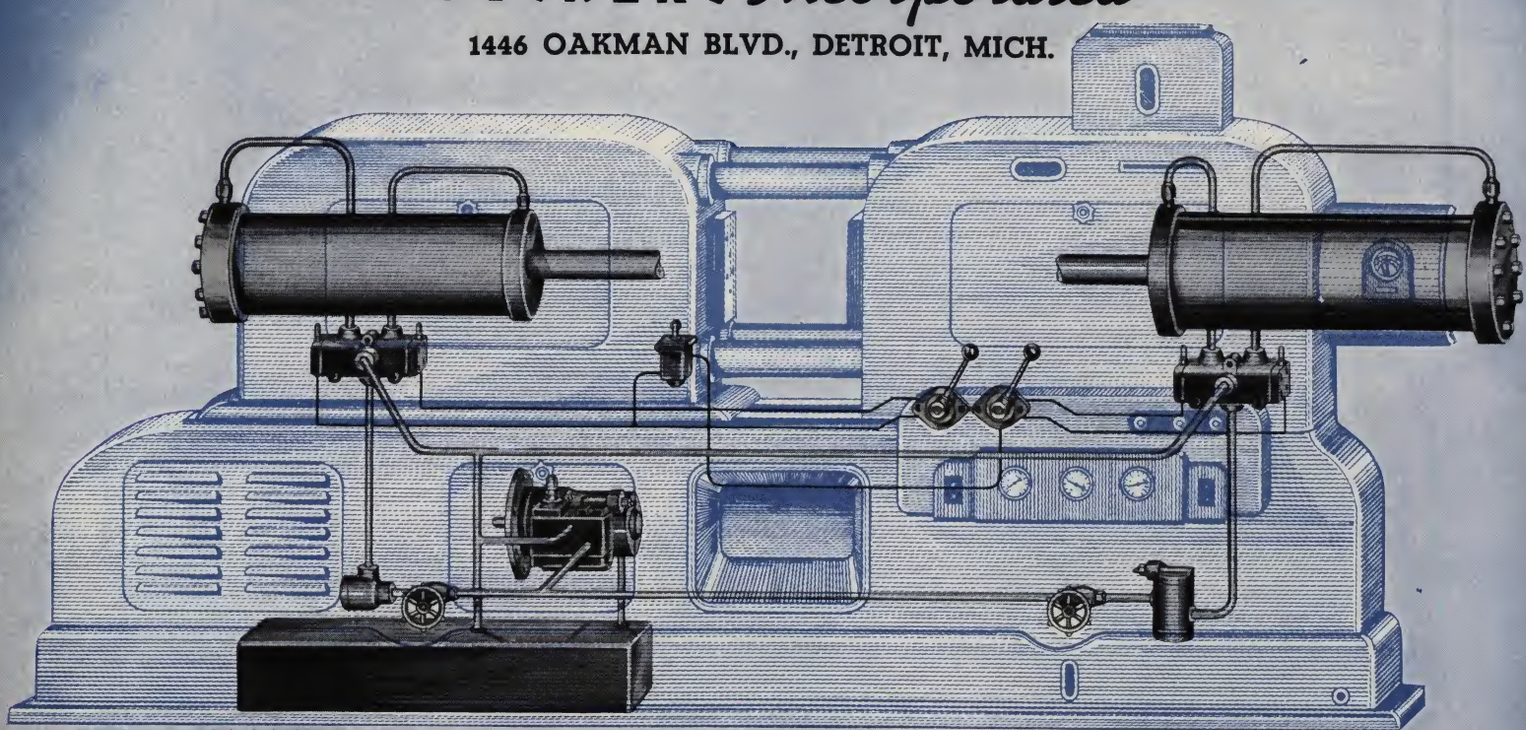
Vickers Hydraulic Pumps and Hydromotive Controls have shown exceptional ability to stand up under heart-breaking service on the toughest installations in press and injection machines. Its record has been so good that "Vickers Hydraulic Equipment" has become the hallmark of a quality press.

Vickers equipment is available to provide any pressure, any speed of cycle, any sequence of operations desired. It does its work quietly, is inherently lubricated, and is remarkably durable.

Other Vickers Products for the Plastic Industry: Prefill Check Valves • Motor Pump Units • Solenoid Operated 4 Way Valves • Solenoid Controlled Pilot Operated 4 Way Valves • Pressure Switches.

VICKERS *Incorporated*

1446 OAKMAN BLVD., DETROIT, MICH.

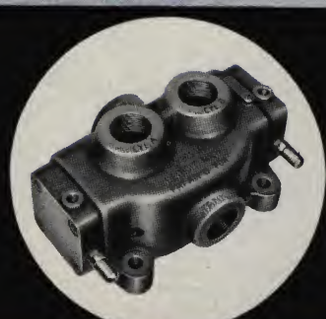




Vickers Check Valve especially designed for high pressure oil hydraulic circuits.



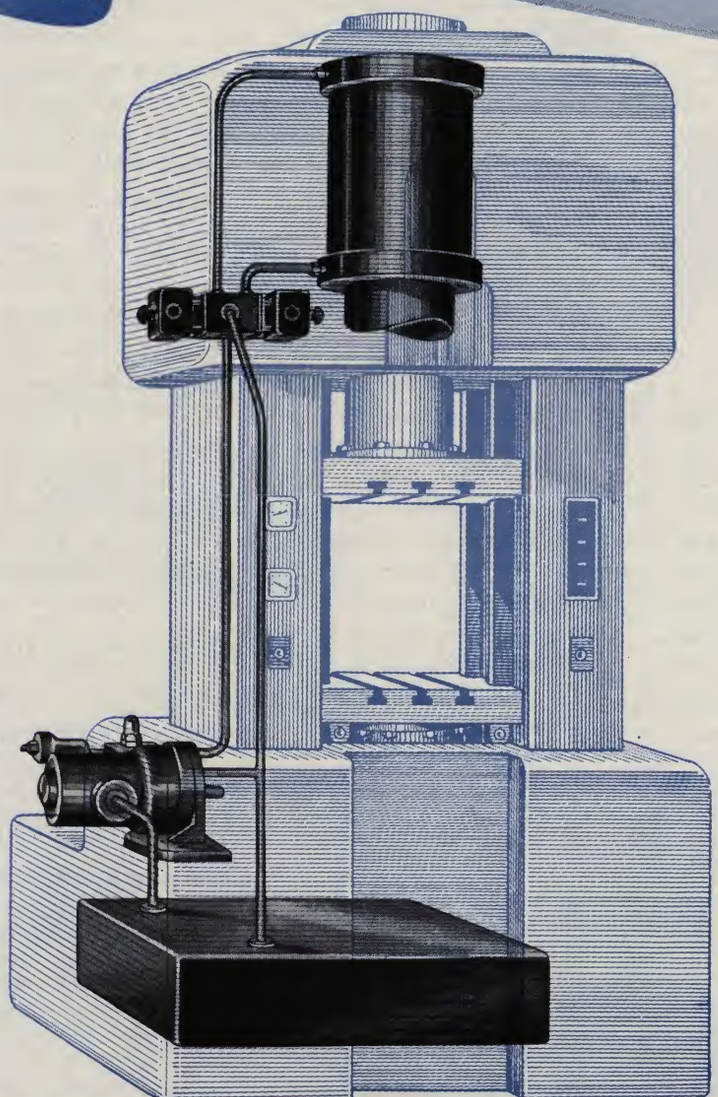
Vickers Pressure Reducing Valve employs new principle for controlling reduced pressures successfully.



Vickers 4-Way Valve supplied in pilot, solenoid or manually operated types for all requirements.

VICKERS

HYDRAULIC PUMPS AND HYDROMOTIVE CONTROLS





Vickers Double Pump and Combination Valve Unit has quiet operation and pressures to 1000 lbs. per sq. in. for continuous duty.



Vickers Variable Delivery Pump has multiple piston variable displacement construction of new and improved design.



Vickers Pilot Valve remotely controls main 4-way valve by fool-proof hydraulic pressure method.



Vickers Adjustable Time Delay Valve hydraulically times sequence of operations.



Vickers Pilot Interlock Valve used to interlock various parts of working cycle for safety or timing.

5



5—An air-ballasted hydraulic accumulator installation by Chas. F. Elmes Engineering Works. Pressure gage panel is pictured at left below. Constant molding pressures are maintained at each press by a steam reducing valve that admits just the right amount to properly heat the mold. As the steam condenses the moisture is drawn from the mold through individual steam traps and returned to the boiler.

Mold heating by hot water, a system that is comparatively new in this country, has been adopted by several of the newer plants. This, too, requires a conveniently placed boiler from which hot water is relayed to the presses, does its job of heating and is returned under full pressure in a closed system—no traps are necessary at the molding presses.

Although centralized heating units predominate, like everything else pertaining to a molding plant, they are not universal. There are shops where each press is supplied with heat by a small individual gas-fired boiler. This permits the operation of one press or a dozen without any heavy boiler installation. One molder has eliminated all steam connections by attaching a miniature, electrically heated boiler to the back of each press. The little boilers cut on and cut off automatically and the temperature can be controlled to close limits. The only use these shops make of a larger boiler is for heating the factory and office in the winter.

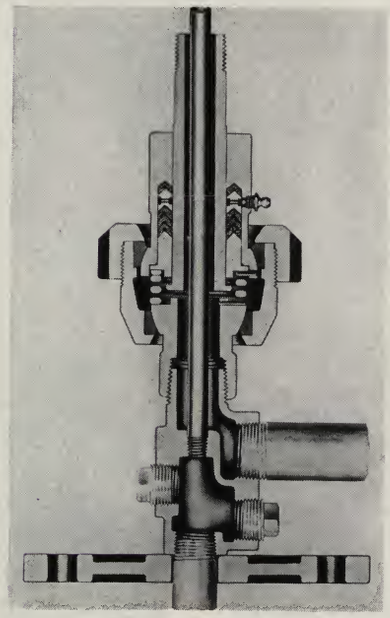
Heat for molding

To get a clear picture of the difference in use of steam and high-pressure hot water, let us first view the generation of heat in the boiler.

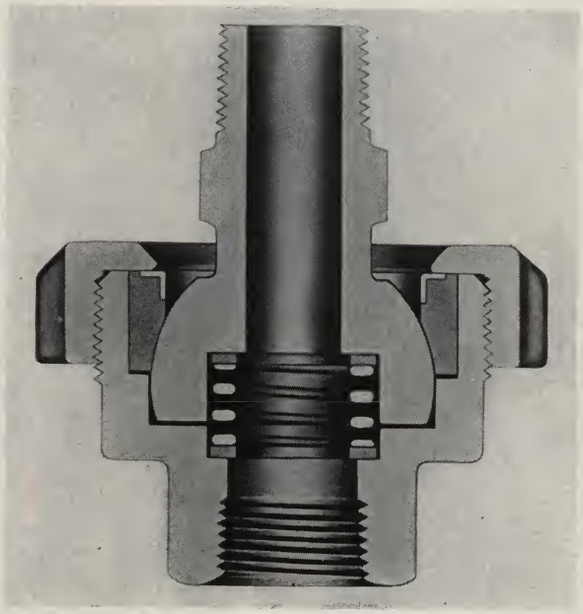
Any standard boiler may be used for either system and it may be fired by coal, oil or gas in the usual manner. An operating pressure is set to obtain the highest temperature required in the process heaters, which, if 350 deg. F. is desired, would be 120 lbs. per sq. in. gage. Water is fed to the boiler and heated up to the boiling point which is 350 deg. F. at the pressure of 120 lbs. per sq. in.

If steam is to be used as the heating medium for process work additional heat must be furnished in the boiler to vaporize the water in an amount considerably greater than required to heat the water up to the boiling point. For instance, assuming that water is fed to the boiler from a hot-well condition of 180 deg. F. at atmospheric pressure and raised to 350 deg. F. at 120 lbs. pressure, it would require 174 British Thermal Units of heat for each pound of water. If then 870 B.T.U.'s more are added to each pound of water it would be vaporized to dry saturated steam at 120 lbs. pressure and still at a temperature of 350 deg. F. This heat of vaporization or "latent" heat is given up when steam condenses in the pipe lines and heating apparatus. (*Please turn to next page*)

6



7

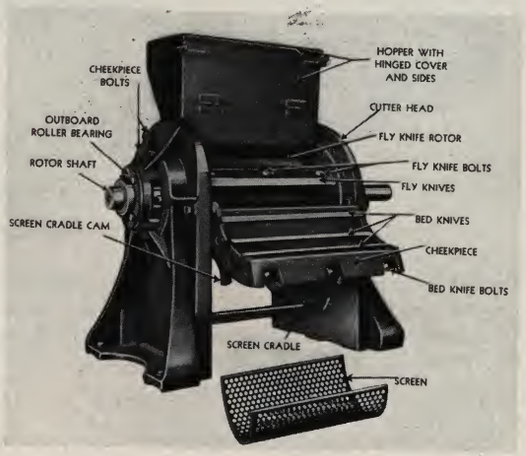


6—Barco swivel joint for application on hydraulic equipment with either oil, gas, steam or water. Designed to withstand alternating steam and cold water. 7—This sectional view of a Barco flexible ball joint depicts automatic adjustment feature which compensates for wear, expansion and contraction encountered with fluctuating temperatures

GRINDING - PULVERIZING - MIXING - SIFTING

ABBÉ ROTARY CUTTERS

The most advanced equipment for grinding thermoplastic scrap, rejects, gates and sprues as well as primary materials in manufacture of plastic powders and many other tough or fibrous materials, resins, chemicals, etc. These cutters embody knife construction; ample screen area, quick opening features and outboard mounting of bearings which assure perfect alignment of knives, uniform grinding to correct mesh, quick removal of product and easy cleaning.



Interior of Cutter, showing smooth rotor, knife arrangement and ease of removing screen. Machine opens on both sides for cleaning and knife adjustment.

Abbé Rotary Cutters have solid, streamlined rotors, smooth steel or stainless steel interior, feed hoppers and discharge chutes built to specific requirements and direct connected or V-belt motor drive. Cutters may be mounted on special portable platforms.



Cutters are available in 5 sizes to cut material from $1/16''$ to $1/2''$ particle size in capacities from 18 to 840 lbs. per hour. Write for Catalog 45B.

ABBÉ JAR MILLS



For batch grinding, mixing or compounding resins, chemicals, button mixtures, etc., in small volumes or multiple batches of different materials in one mill, Abbé Jar Mills offer a wide variety of capacities and arrangements, producing results comparable with those in Ball Mills. Jars made of porcelain, steel, stainless steel, etc., arranged in single or multiple frames holding from 1 to 18 jars. Write for Catalog 47.

ABBÉ BALL and PEBBLE MILLS

For fine grinding, mixing and blending resins and chemicals in manufacture of molding powders, and for grinding of pigments in resin vehicles, Abbé Mills offer time, labor and equipment saving. Ball Mills of chrome manganese or stainless steel; pebble mills lined with highest quality porcelain blocks. Special method of coolant distribution in jacket assures uniform temperature throughout the *entire length* of the mill. All welded construction, heavy mountings and any drive desired. Mill capacities from 40 to 13,000 lbs. Write for Catalog 49.



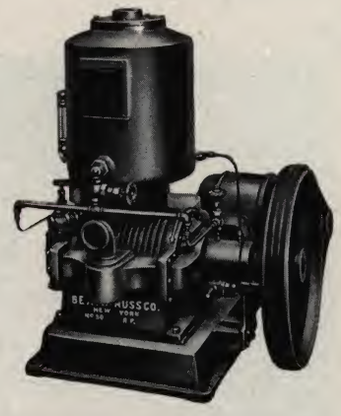
ABBÉ IMPACT MILLS

For scrap and rejects from thermosetting plastics, this mill pulverizes to coarse, medium or fine mesh at high rate and low power cost. Design of toothed concentric rings provides for maximum grinding surface and high rate of production. Easy to clean and change screens. Capacities from 400 to 4000 lbs. per hour. Write for Bulletin 46.

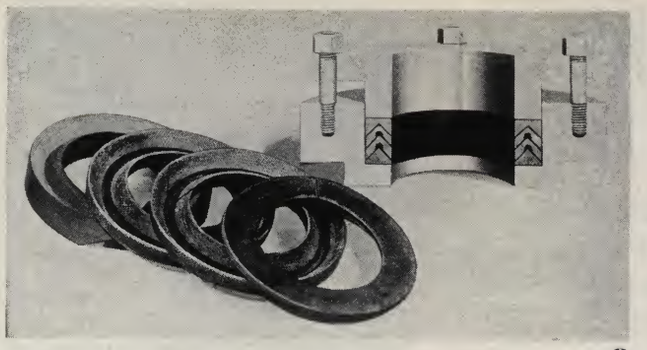


BEACH-RUSS VACUUM PUMPS

Assured high vacuum above 29.75" Hg. for chemical distillation, drying, cooking, curing, packing, etc. Patented rotary design and lubrication system assure high volumetric efficiency at low power consumption and low operating speed. Corrosion resistant construction and precision fitting assure maximum efficiency and long service life. Capacities from 15 to 1100 C.F.M. Write for Bulletin 74.



ABBÉ ENGINEERING CO. 58 Church St. . . . New York, N. Y.



8

8—Efficient molding plant operation requires serviceable packing with high operating line pressures. It is of vital importance to have leakproof packing as this is by Garlock Packing Company

If, however, high-pressure hot water is to be used as the heating medium it is unnecessary to go through the vaporization part of the cycle in the boiler. Water that has been heated to 350 deg. F. at 120 lbs. pressure is withdrawn from the boiler and circulated through the mains and presses by means of a pump and returned direct to the boiler still under full pressure. In passing through the presses the water gives up heat and is reduced in temperature a certain amount but not in pressure. One pound of water gives up one B.T.U. for each degree F. drop in temperature so that it is necessary to pass through sufficient water to accomplish the heating with the desired uniformity of temperature. What heat is not used goes directly back to the boiler in the return water, which replenishes what has been used in the presses plus a small amount lost owing to radiation from the insulated mains. We have seen that in the steam boiler both the water before evaporization and the dry saturated steam at 120 lbs. gage pressure are both at 350 deg. F. From the steam tables we find that under these conditions of pressure and temperature the water weighs 55.6 lbs. per cu. ft., whereas steam weighs only 0.3005 lb. per cu. ft.; and, what is important to consider, that one cubic foot of water contains a total heat of 17,870 B.T.U.'s, whereas one cubic foot of steam contains 378 B.T.U.'s. In other words a given volume of high-pressure hot water contains 50 times the heat of the same volume of steam.

We see that the water system acts as an accumulator of heat with a large reserve capacity to take up any sudden loads without reduction of pressure, which in a steam system would mean reduction of temperature. Also, if we make allowance for the difference between the ordinary velocity of steam and that of water in the piping, we find that a given size of pipe will pass five times the amount of heat in water than in steam, thus making for a much greater uniformity of temperature throughout the system and affording the opportunity of using smaller piping and valves.

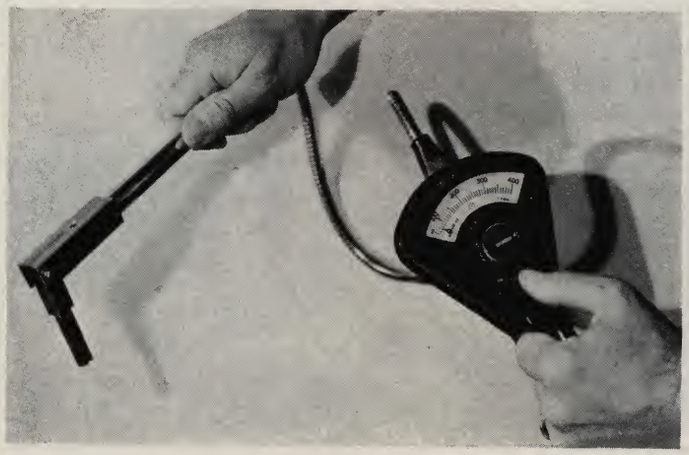
Hydraulic controls

This equipment is used to open and close the presses and apply pressure. The usual procedure is to close the mold slowly at low pressure (250 to 500 lbs. per sq. in.) giving the plastic material time to heat and soften thoroughly before the high pressure (2000 to 3000 lbs. per sq. in.) cuts in, forcing the viscous substance into every nook and cranny of the mold that imparts shape and form to the finished piece. After the proper amount of curing time has elapsed and before the pressure is released, cold water, in some instances, is allowed to flow through channels built into the die, chilling the molded part for ejection.

Both high and low pressure lines are actuated by an accumulator, which hoards pressure to be drawn upon as needed; a pump, which forces enough liquid into the accumulator to keep it well charged; and controls, which regulate the admission of this element at each press.

Any one of several different types of accumulator may be chosen depending somewhat upon the size of the shop and the space that is to be allotted to it. There are weighted accumulators—one has a vertical ram loaded with cast iron or concrete blocks, the number of which may be varied for different operating pressures; another has a tank filled with iron ore, steel punchings, pig or scrap iron, etc. Because of the tremendous weight of these particular pressure storehouses, they must be set up on a firm foundation. A compressed air ballast type of accumulator, charged with air and filled with liquid to the required working pressure, requires no special

9



10



9—To test mold temperatures when establishing conditions or to check operations pyrometers as this by Cambridge Instrument Co. Inc. are used. 10—R. W. Cramer Co. automatic reset timer used to control the press cycle

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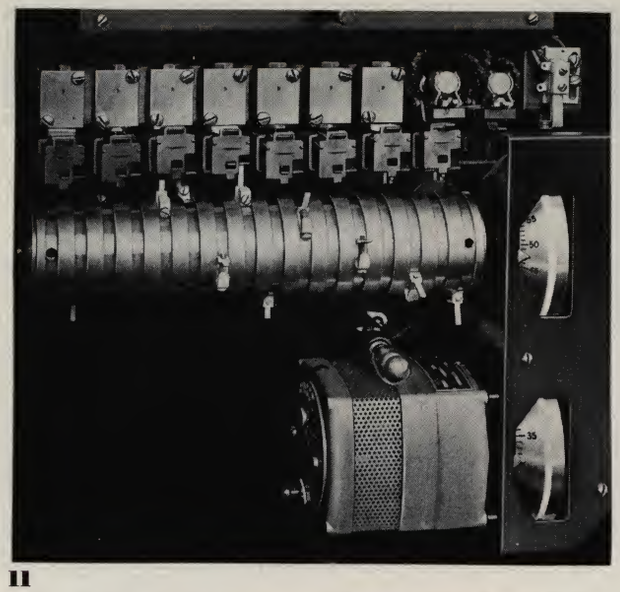
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3. Saving of the resin which formerly had to be baked on the kettle wall and then chipped off by hand.
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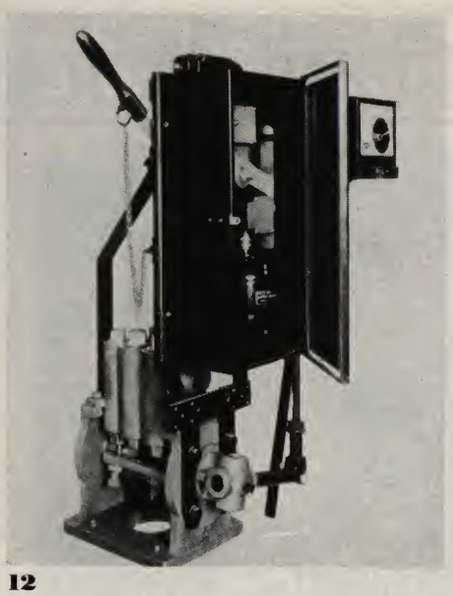
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11



12

11—Taylor Flex-O-Timer showing 8 latch operators, 7 air valves and 2 mercury switches. Timer is applicable to all pneumatic or all electrical operations or combinations of these. 12—Time cycling equipment by Automatic Temperature Control Co. Inc. for operation of hydraulic presses

foundation for installation and occupies little space.

The pumps that service the accumulators may be horizontal or vertical, whichever fits best into the layout of the equipment. Belt or motor driven reciprocating pumps of two, three and four plungers are popular for supplying high pressure liquid with a centrifugal pump for low pressure. There are some steam-driven and motor-driven reciprocating pumps that take care of both high and low pressure lines.

Control valves at each press may be manually or automatically operated but the consensus of opinion is that automatic controls make for more accurate timing and better molded pieces.

In the early days of the plastic molding industry when hand molds were used almost exclusively, the question of controls for the hydraulic plastic molding press was comparatively simple. It was then only necessary for the equipment manufacturer to have in mind the source of pressure supply, that is, whether the press was to be operated from an accumulator system or a direct pumping unit. If pressure was obtained from an accumulator system, the simplest type of stop and release valve was required, although of course in some instances where both high- and low-pressure accumulators were employed, an additional valve was used for automatically admitting high-pressure liquid when the low pressure had reached its limit. Similar systems are still demonstrating their worth in modern molding plants, by automatically conserving high pressure liquid instead of leaving the change-over from low pressure to high pressure in the hands of the operator.

In the case of the self-contained press, that is, the press with its individual pumping unit—and before the development of the rotary type pump—units similar to that shown were often used. In some instances the reciprocating or plunger pump was not mounted on the press, but arranged as a separate unit placed adjacent to the press. With such installations, a simple stop valve was used as a release, and an adjustable type by-pass valve employed to by-pass the pump and maintain pressure during the curing cycle.

These systems apply to the hand mold type of press and therefore, no pressure was required for opening the press at the end of the curing cycle, since the molds were parted after removal from the press.

With the development of what is commonly known as the semi-automatic type of plastic molding press which involved the loading and unloading of the molds without their removal from the press, it was found that additional pressure was required for stripping the pieces from the molds. This necessitated what is commonly known as pullback cylinders on the presses, and the general practice was, and still is in many instances, to float these pullback cylinders on the accumulator line. This of course required the use of a three-way operating valve, either of the two-stem handwheel operated type or of the single-stem rapid-acting type, or the balanced spindle type.

In contrast to floating the pullback cylinders on the line another common practice is to admit hydraulic pressure to the pullback cylinders only when this is required for opening the press. To do this requires the use of a four-way operating valve, either of the three-stem handwheel operated type, or of the four-spindle type.

It must be understood that the above-mentioned valves are all of the type suitable for installations where accumulator water is used as a pressure medium, and that in many instances valves of a simpler and less costly design can be employed where oil is the pressure medium, on self-contained presses such as the piston type.

In recent years the perfection of various types of rotary oil pumps has resulted in a number of important and desirable changes in press control mechanisms, and has



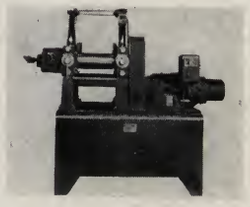
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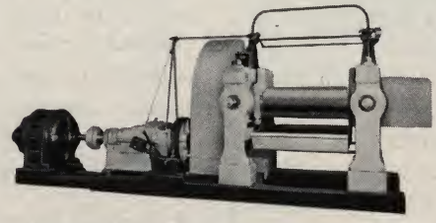
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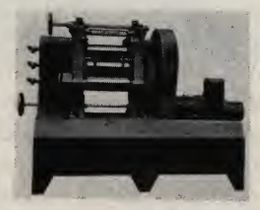
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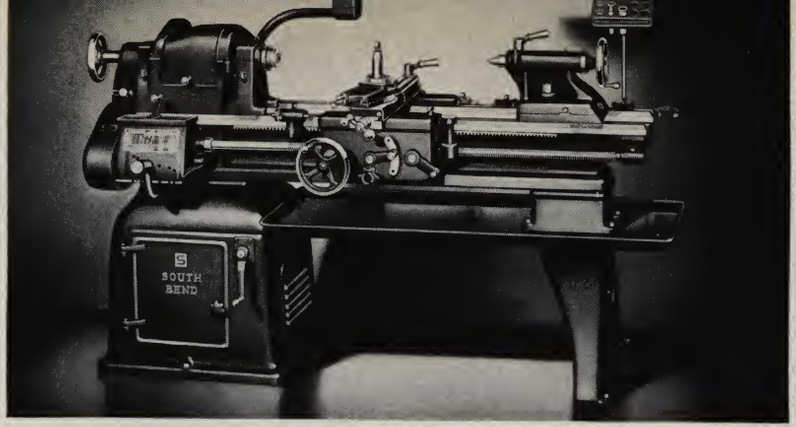
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13

13—South Bend Lathe Works, Inc. 14½ in. swing underneath belt, motor-driven tool room lathe used in machining large diameter parts for molds and fixtures

been instrumental in bringing about the popularity of the self-contained plastic molding press. The use of these pumps has made possible a less costly, more compact press unit, combining pumps, motor and controls in one housing, for a more pleasing general appearance.

In describing the cycle of a self-contained unit, the low-pressure pump by-passes after the molds have been brought together and pressure starts to build up. In some instances it is not desirable to bring the molds together under the rapid advance speed. It is then possible to actuate the low-pressure by-pass valve by mechanical or electrical means, so that the rapid advance speed of the press ram can be cut off at any desired point, this point being adjustable. When this occurs, the high-pressure pump continues to move the press ram at a greatly reduced rate of speed, thereby closing the molds gently and without shock. The time cycle control which is now in use on many presses is simply a standard make of electric timer which can be set to maintain pressure on the work for the required length of time. When this time has elapsed, an electrical contact is made with a solenoid-operated four-way piston type valve which immediately exhausts pressure from the main ram and directs the flow of the pump to the pullback cylinders—or, in the case of the double-acting ram, to the pullback side of the main ram.

As in closing, it is sometimes also desirable to open the molds slowly for a short distance, in order to protect inserts, etc. A similar means to that described above can be used for actuating the low-pressure by-pass valve, so that the large volume pump discharge is not directed to the pullbacks until the molds have been opened the desired distance. The press then opens under the rapid advance speed.

In summarizing, it will be found that molding presses can now be equipped with such control mechanisms that the operator, after filling the mold cavities with the material has simply to push a single button, automatically starting a complete cycle which can include all of the various steps that may be required in handling the more difficult type of pieces. This leaves the operator free to proceed to the next press and perform the necessary unloading and reloading operations.

Air compressors

These usually supply a constant volume of air in any part of the shop wherever its function is desirable: at each press, to blow left-over particles from the mold between cycles, and sometimes to help eject molded parts; at finishing machines, to remove grindings and dust from molded pieces and working surfaces; in the pilling room to clean preform presses and their surroundings between runs of different colored materials. Where an air ballast accumulator is employed, the air compressor gives the unit its initial charge and makes up any losses of air that may occur from time to time.

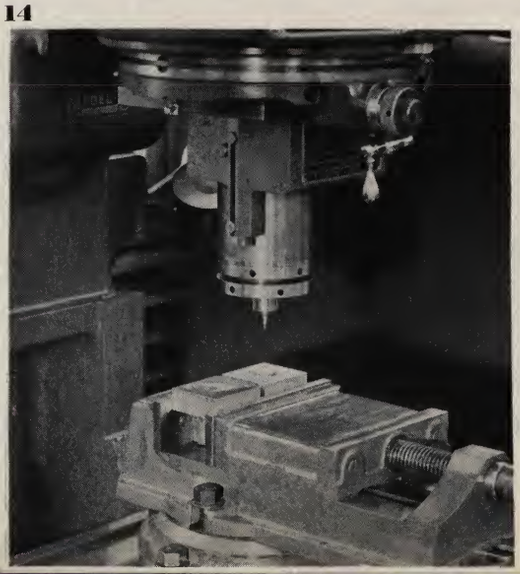
Water salvage system

This is essential to reclaim the vast quantity of water necessary in conducting molding activities and prepare it for re-use through regular channels. Because in certain sections of the country water represents a considerable item of expense, some shops find that it pays to install appropriate salvage equipment. This helps bring the cost of water to its proper level among other operating expenses.

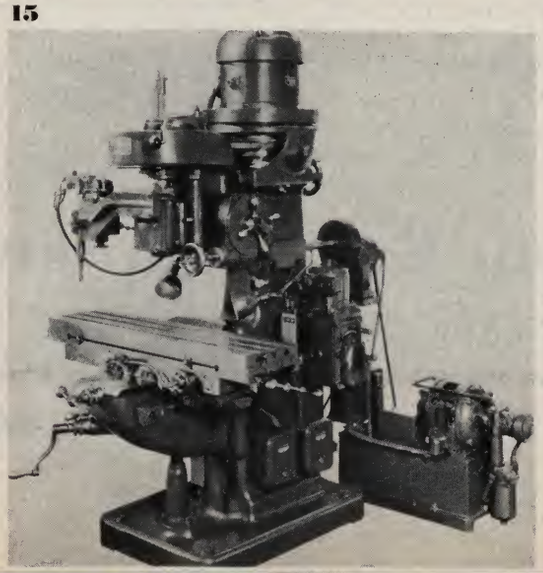
A compact system of piping

Such a system is needed to carry steam, low hydraulic pressure, high hydraulic pressure, cold water and compressed air from their source in the power plant to the particular sections of the shop where they are used, to-

14



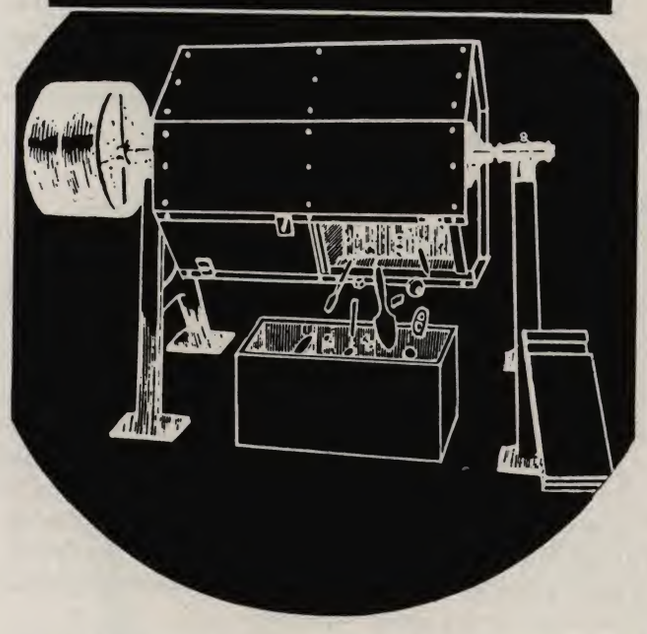
15



14—Two halves of mold still in place in vise of Milwaukee die milling machine after finishing. (Photo, courtesy Kearney & Trecker Corp.) 15—Reed - Prentice vertical miller for die making has varying spindle speeds

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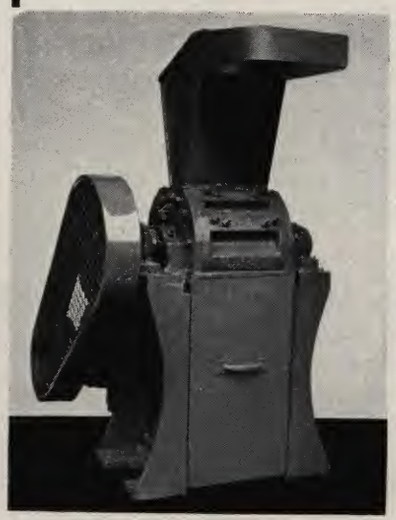
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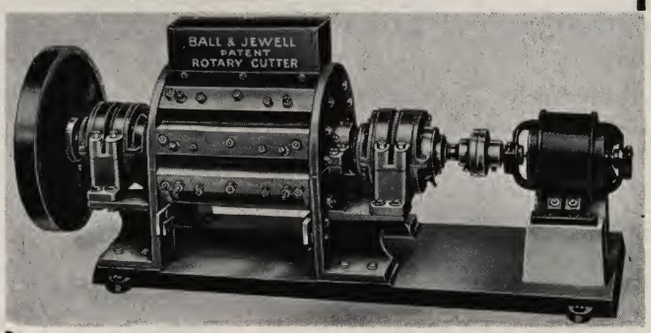
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gether with hydraulic, condensate and warm water return lines. Piping in early shops more often than not resembled a huge octopus suspended from the ceiling with a confusing network of limbs spread out in all directions. Overhead piping is still considered good practice by some, but the lines are arranged in even, direct formation and a color code is usually adopted so that it is an easy matter to tell one line from another. Underground piping is another favored method of installation. The pipes are carried along in a trench that may be covered with boards making this section level with adjacent flooring. The boards, of course, can be removed whenever maintenance work is necessary. By a third method, pipes are arranged horizontally in parallel lines behind a row of presses or perhaps between two rows of presses placed back to back. A trench directly below catches and disposes of any drippings there may be, making it possible to keep the floor clean and dry at all times.

Flexible metal tubing or swivel joints

Flexible metal tubing or swivel joints are used to convey steam and water from the main lines to the press, and return. The conveyors chosen must be capable of withstanding quick changes in temperature as first steam, then cold water, pass through them. They must be pliable, to bend and straighten with the continuous up-and-down movement of the press platens.

Packing

Packings are used to hold the pressure which lifts the main ram of the molding press in closing. These must be tough enough to stand up under the strain of constant motion, and resistant to heat and pressure. The nature of the packing differs according to the degree of heat being used at the press. Cup or "U" type oak-tanned packings are found to be adequate for lower temperatures, while chrome-tanned packings are more satisfactory where temperature is held at a higher degree.

Temperature and time control

Temperature and time are two most important factors in producing molded parts. If the temperature is uneven, if it is too high or too low, defective pieces begin to come out of the mold. They may warp, shrink and discolor, the surface may be rough and blistered and they are of no use to the molder or anyone else. Therefore, once the proper temperature has been determined for the material being run, the mold cavities are checked from time to time to make sure there is no variation in heat. Pyrometers are useful for this purpose and they are available in a variety of styles and sizes.

Manually or electrically operated timing devices, attached to each press, that flash a light or ring a bell when a cycle has been completed are favored by many. These usually operate on 30 sec. to 10 min. periods. A master electric clock, placed so that all can see it, is helpful for timing longer cures.

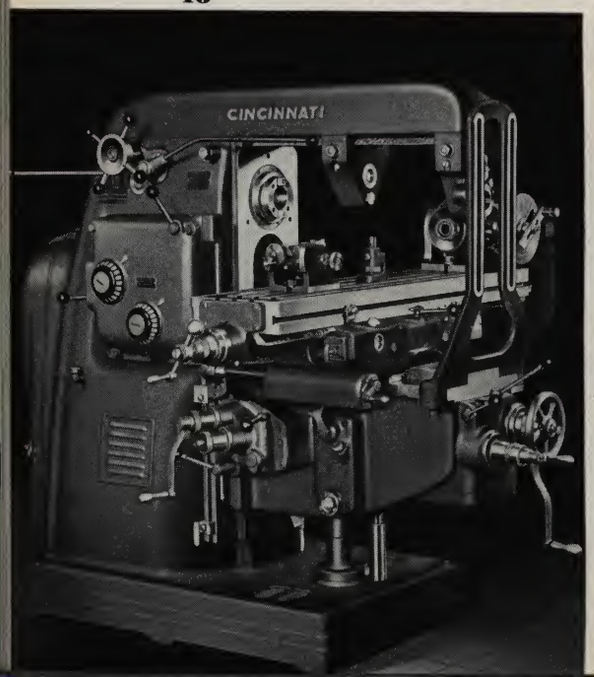
Tool room

All-important, die making has often been called the "bottle-neck" of the plastics industry. Two or three weeks and sometimes more, these days, is required to transform a solid block of steel into an efficient, workable mold. The customer, sold on the idea of using plastics for his product, can hardly be blamed for becoming impatient long before the first of his moldings comes from the press. To control such delays as far as possible and speed up the production of dies, many molding plants have invested in a complete drafting department for designing molds and a tool room where the drawings are translated into steel.

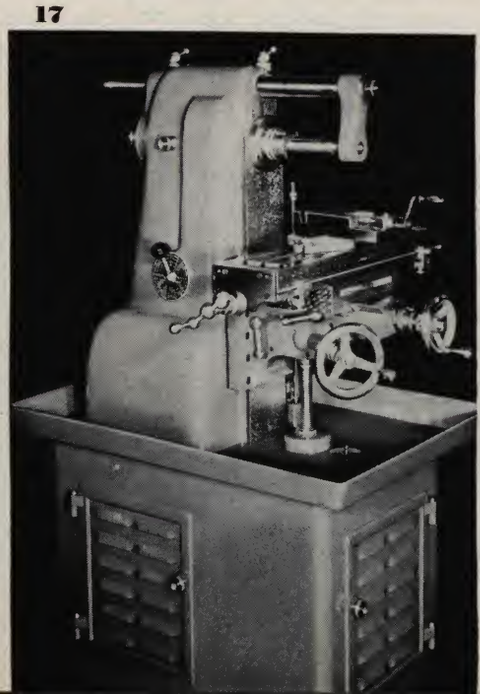
Mechanical saws, planers, shapers, milling and die-sinking machines, grinding wheels, lathes and drills of all sizes are used for cutting, grinding and shaping original cavities. Hobbing presses and duplicating machines

16—Cincinnati milling machine with precision controls and completely variable speed power units. 17—Hardinge milling machine, a compact unit which still has a large working surface. High spindle speeds are a feature. Feed screws revolve in long adjustable nuts and have large friction dials graduated to thousandths of an inch. 18—Cantilever type truck by Lyon Iron Works for transporting, raising and lowering molds. Capacity 1000 lbs.; platform 30 in. by 36 in. Winch for pulling dies on and off

16



17



18



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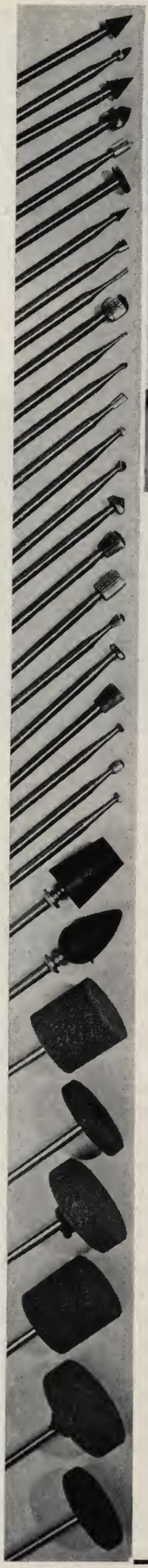
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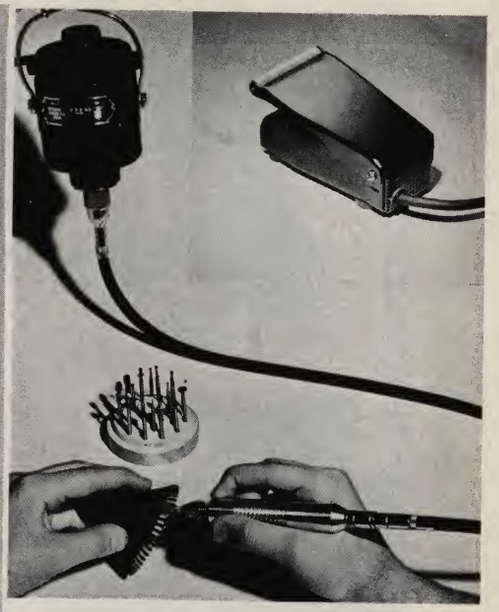
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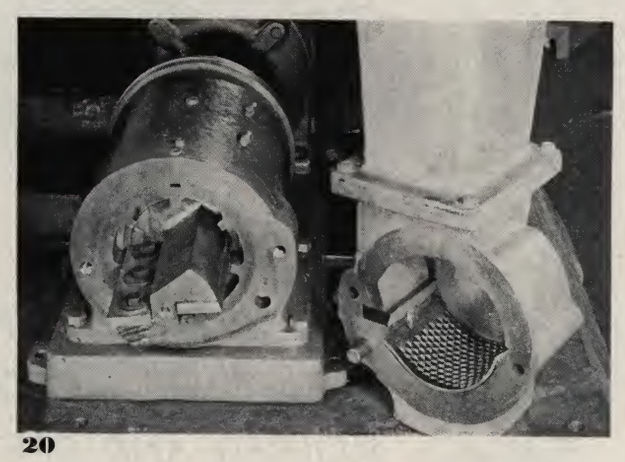
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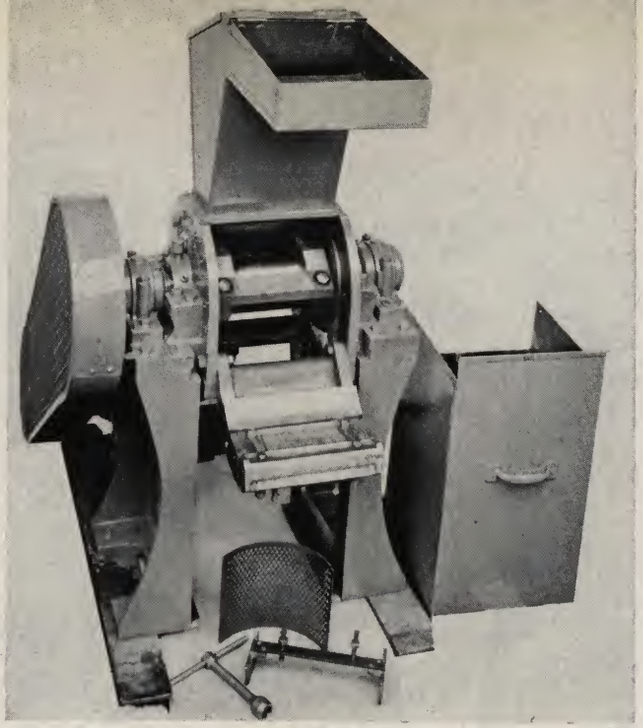
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19



20



21

19—Abbé rotary cutters suitable for grinding new material or gates and sprues. 20—Ball and Jewell texrope-driven grinder. Hopper designed to prevent material from flying out during grinding. 21—End view of Cumberland cutting machine with housing removed to show rotating part and knives. Close spacing of knife ring results in accentuated cutting action

quickly and economically reproduce identical cavities from the originals.

Every shop has an assortment of lathes, milling machines, hack saws, surface grinders, tool grinders, punches and drills for repairing molds and keeping them in good working order. It also provides space for convenient storage of idle molds.

Powder storage

Molding compound, delivered in huge drums, must be classified as to color and type and stored in such a manner that it can be used in the same order it comes into the shop. Racks, in tiers, serve in some plants as a convenient method of accomplishing this. Incoming drums of material are hoisted onto the rear end of the proper rack while the drums to be used are rolled off the front end.

Air conditioning or at least controlled temperature is important in the powder storage room. There is a certain amount of plasticizer or lubricant in the material when it arrives at the plant. If a drum is partially used and then allowed to remain in a room that is too hot or too dry, some of the plasticizer or lubricant is bound to evaporate and when that compound finally reaches the press, it does not give optimum results.

Preparation of powder for molding

Because, for the majority of applications, loose powder is bulky and difficult to manipulate without a lot of waste in material and time, it has become customary to compress it into pills or tablets called "preforms."

Preforms may be large or small, round, oblong or square depending on the size and shape of the piece to be molded. Some shops go in for rather elaborate preforms that closely resemble the actual shape of the finished molding. The tablets are reasonably solid and certainly easier and cleaner to handle than loose powder but they do break and chip at times and if these damaged pills are allowed to enter the mold, imperfect plastic parts are likely to result. (See page 198.)

It is common practice to separate preform presses by partitions or booths. This is especially true of those operating on colored materials since the tiniest speck of a different color will show up in the finished molding.

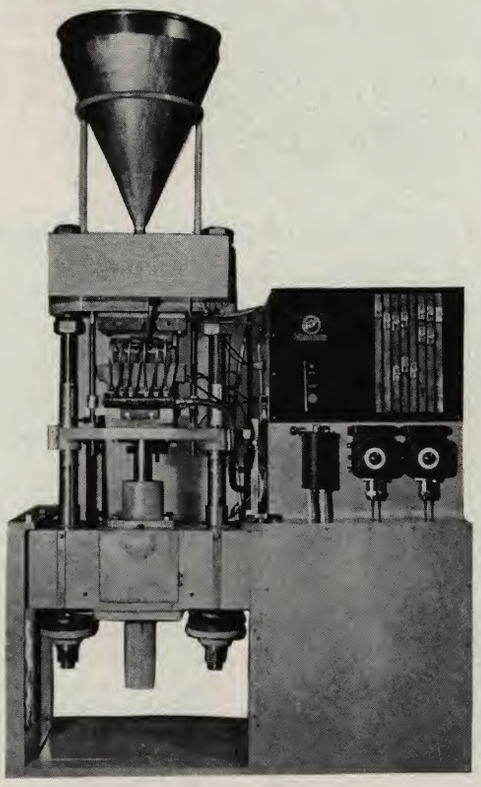
To avoid as much waste as possible each charge of loose powder, which is still used, and it is extensively, must be measured as accurately as are the preforms. It may be weighed into suitable containers by hand on an accurate scale, or measured automatically by machine at each press. In a simple method adopted by one shop, an original drum of molding compound is fitted with a funnel at its dispensing end and suspended between two pipes at each press. The press operator holds his loading board under the funnel, releases a spring cap, and the powder drops into the cups as he slowly moves the board back and forth to catch it. By this method little powder is lost and no dust can enter the drum of material.

(*Please turn to next page*)

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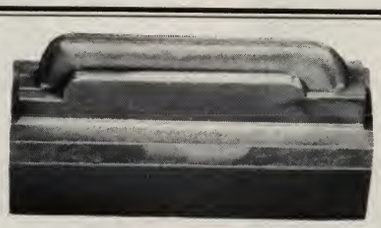
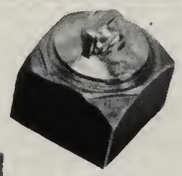
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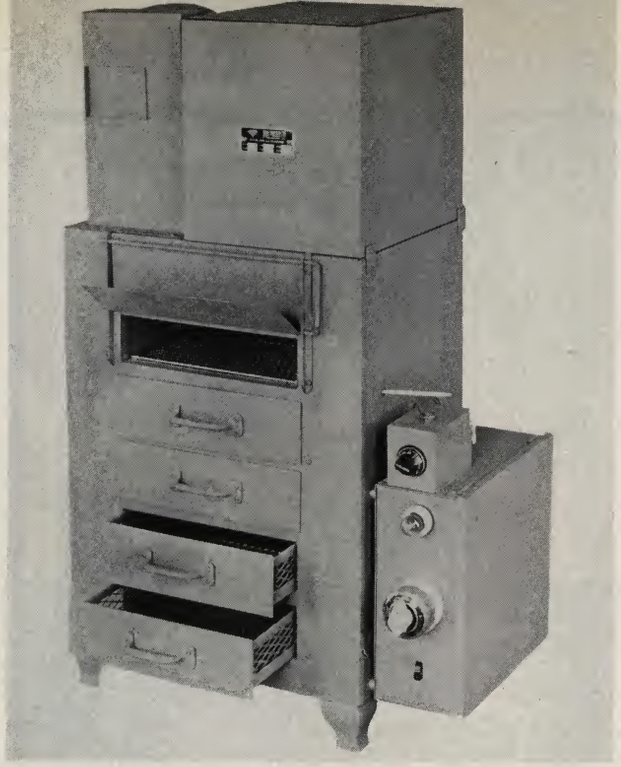
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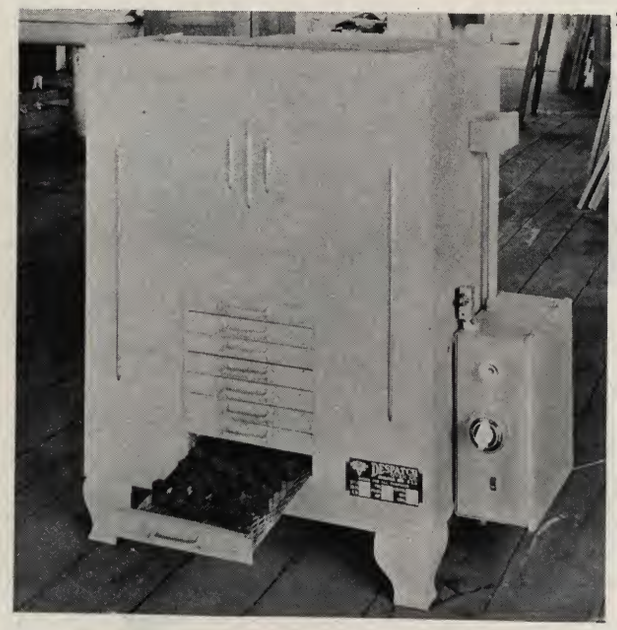

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22

22—Electrical oven for conditioning materials prior to molding. This is a combination flap type door and drawer unit. 23—Forced air circulating system and automatic temperature control are both built into this 8-drawer preheating oven. (Both by Despatch Oven Co.) 24—This Chas. F. Elmes oven is made with four, six or eight drums to meet predetermined capacity requirements



23



24

Preheating ovens

Preheating may range all the way from warming the material at 100 deg. F. up to the ultimate, where the material is heated at 250 deg. F. to 290 deg. F. for 15 to 30 minutes and is truly in the plastic stage when put under pressure in the dies. This latter stage is to be desired but can only be achieved if the molder is a highly skilled operator who will hold to a given cycle with little variation, as any slip which causes him to miss a cycle, or unduly prolong one, will result in a tray of pills so far advanced that the material cannot be molded.

One of the most successful preheating ovens used today is made by the molder himself. It consists of an insulated chest with a door on the front equipped with hinges at the bottom and a spring catch. This oven is roughly $2\frac{1}{2}$ ft. by $3\frac{1}{2}$ ft. by 18 in. deep, measured on the inside dimensions, and has a serpentine coil of $\frac{3}{4}$ in. pipe along the inside bottom, back and two ends, through which exhaust steam from the presses flows to supply heat. The oven has two shelves formed by metal rods on which rest eight perforated metal trays. These ovens are placed on the work bench before each press and are heated to 290 deg. F.

If the job in production requires a fairly long cycle, the molder may use only three trays. On the other hand, with a short cycle all eight trays may be used. In any event, the pills are heated until they are thumb-nail soft and may be distorted with slight pressure.

The ideal preheating oven should have the following characteristics:

1. Uniform temperature in all parts of the oven.
2. Circulating air by means of either natural draft or by the use of fans.
3. Some means of regulating the temperature to a ± 5 deg. F. limit.
4. Trays for at least 8 mold charges.
5. Good insulation.
6. Trays should be readily accessible.
7. Small over-all dimensions so that an oven may be placed on the work bench before each press.

Recently manufacturers of ovens have designed equipment specifically for the molding industry, and several ovens have been offered which fulfill the above requirements.

Major efforts to date by one of these manufacturers have been on the drawer type or sectional type units. They offer many advantages and more nearly fulfill the requirements of an ideal, all round type.

Accessory press room equipment

In the gradual process of developing the molding process, it has been learned that preliminary heating of powder or preforms has very definite advantages. For one thing, it shortens the molding cycle considerably since preheated material is already well on the way toward softening when it is loaded into the die. And the shorter the cycle, the greater the number of pieces turned out by each press during a working day.

(Please turn to next page)

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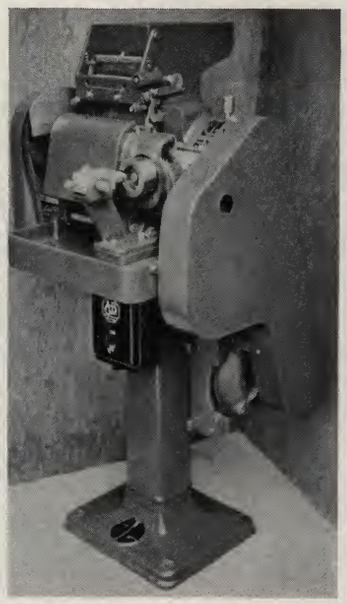
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Then, too, parts molded from preheated material are claimed to be more uniform, better appearing and to have improved dielectric qualities and heat resistance.

For quick, competent filling of cavities, loading boards are designed to fit each mold as it comes along although they all follow the same general pattern. The boards, made of wood or lightweight metal, are built with the same number of depressions as there are cavities in the mold. Preforms spread across the top drop into each hollow; the loader is accurately spaced over the lower die; a sliding plate is removed from the bottom and the preforms drop into place in the mold cavities. Powder loaders, of course, must be made with larger cavities but along similar lines.

Each pressman needs a good sized bench or table for the business of preparing his loading board, for his supply of molding material, for metal inserts if they are to be used in the piece he is molding, and for the assortment of tools that he uses on the job, as well as protectors of one sort or another that help prevent his being burned or otherwise injured at his work. Among his tools are hammers, plyers, tweezers and scrapers, along with special gadgets that he may need to unscrew or eject pieces from the mold.

Hand-operated arbor presses are usually installed wherever hand-molds are being used. The hot mold is clamped into the press, separated and the part taken out in a minimum of time.

The press room is not complete unless some provision is made for inserting and removing large, multiple-cavity molds from the presses. Cranes or overhead pulleys may be preferred or an elevator-type truck that raises the molds to the level of the press opening where they are pushed and tugged into place. Placed in a convenient corner in many press rooms, is a de-greaser where all dies are treated before being hoisted into the press, to remove every trace of the oil or grease that has been smeared on to protect their surfaces.

Finishing, inspecting, packing

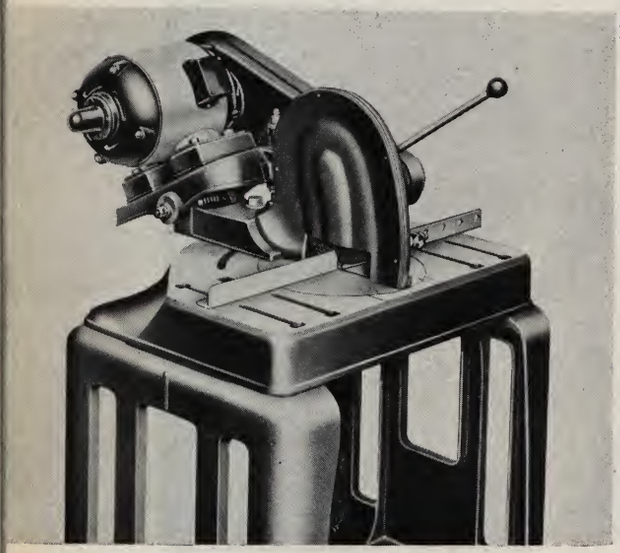
As a rule, when the molded plastic part, whether it is a handle, a bottle cap, a tray, a box or an electrical attachment, comes from the press, there is a certain amount of overflow material or thin flash clinging to it that has to be removed. With small pieces this is best accomplished by rolling them together in a rapidly rotating tumbling barrel until the flash has been broken off.

Superfluous material is removed from larger pieces by machine grinding on horizontal and vertical belt sanders or by hand filing. Holes for assembly devices or inserts, not always practical to mold into the part, may require high-speed multiple-spindle drill presses and tapping machines. Holes that are molded in are likely to be closed with a thin film of flash which is forced out on a punch press and then polished. These finishing operations are fully described in a separate article in this issue, page 244.

Packing equipment is about the same as that used in any other shipping department. Small parts may be poured into cartons, the correct number usually being determined by weight, and no further interior packing is necessary. Large pieces are sometimes wrapped or separated by partitions in the carton to avoid any possibility of their being scratched.

The modern molding plant is a properly lighted, well-ventilated unit. Natural daylight is utilized as far as possible, augmented wherever necessary by intensive

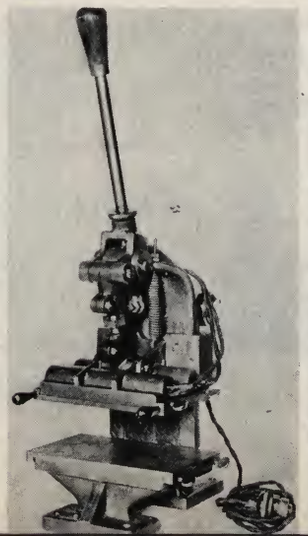
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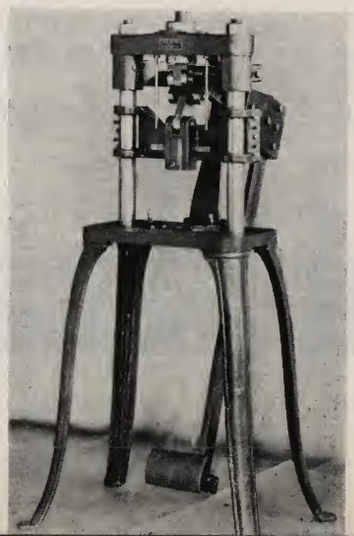
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27



28



25—Delta cut-off machine for quickly and accurately cutting to exact lengths cast, laminated or molded materials. 26—Portable flexible shaft machines by Stow Mfg. Co. may be adopted for grinding, sanding, wire brushing, drilling, buffing or polishing by changing the contact part. 27—Small equipment for light pressing, swedging or cementing operations are sometimes used in pairs where production warrants. 28—Toggle press equipped with knock-out head, can be adopted for cutting sprues from injection molded pieces. (Both by Standard Tool Co.)

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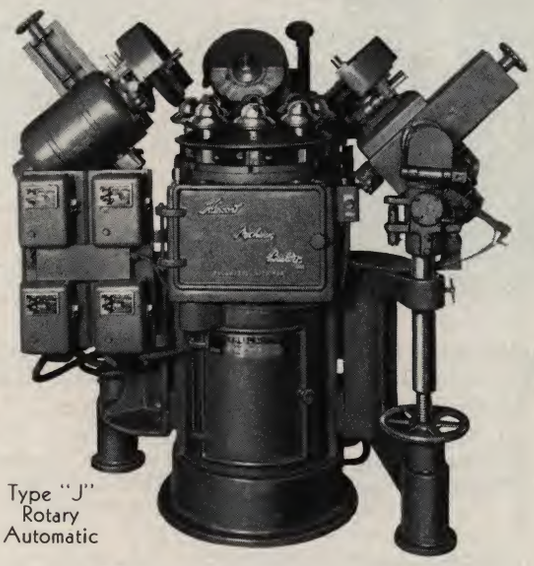
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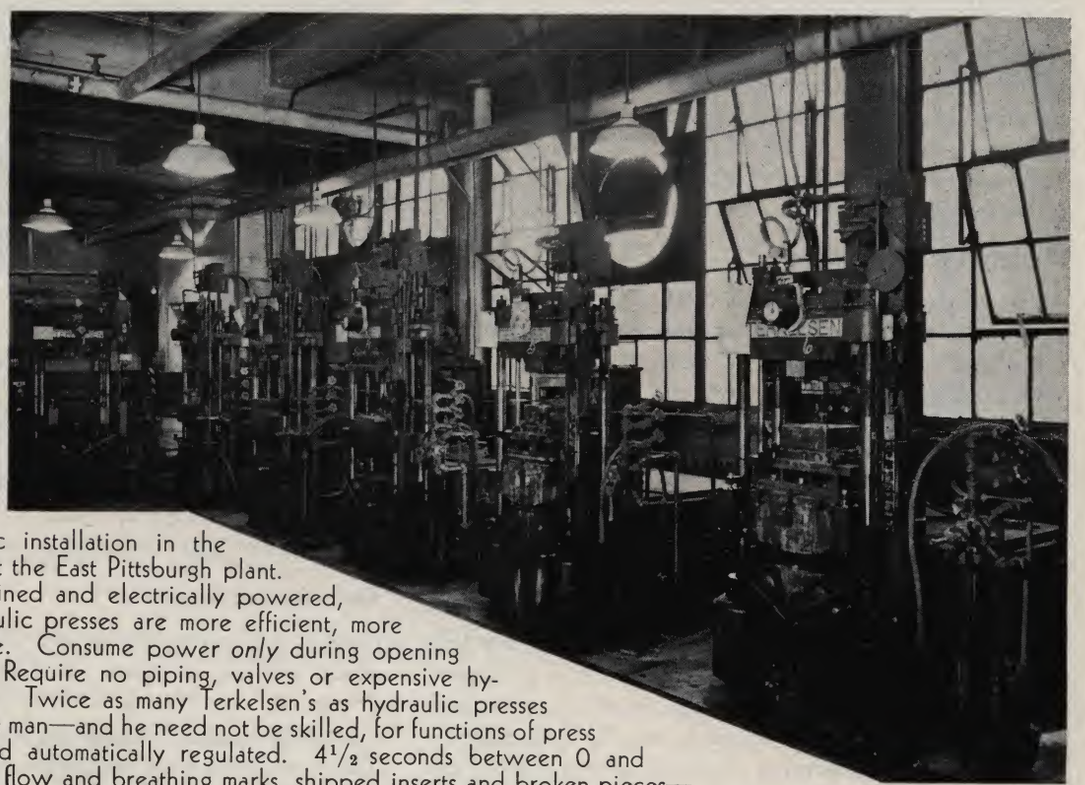
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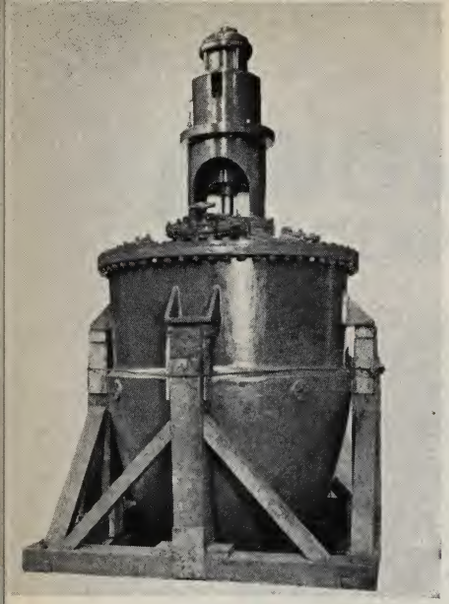
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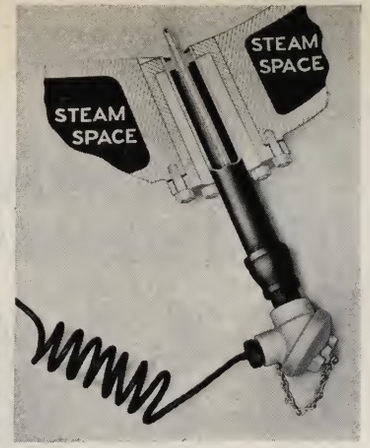


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29



30

29—Resin kettle equipped with positive-action scraping agitator. The unit is of one-piece cast reinforced construction. 30—Thermocouple designed for use on mixing kettles. Constructed to give accurate readings when used on this class of equipment. (Photos, courtesy Sowers Manufacturing Co.)

overhead illumination or individual droplights that can be adjusted to fit the needs of each worker. Excessive heat caused by the operation of presses is removed by electric fans or blower systems.

Although the apparatus mentioned is essential to any capably run plastics molding plant, each shop has an individuality all its own. In custom molding, particularly, because each job has its own peculiarities, its own exclusive requirements, each molder works out his own methods and tools for handling it. Automatic machinery has a tendency toward eliminating some of the finishing operations and there won't be as much flash to remove or as much buffing and polishing to be done, although small parts probably always will be tumbled and some large parts will look better if polished.

Resin plant equipment

The design of resin plants is often a difficult problem involving critical heat-transfer problems, dehydration problems, foaming problems, refluxing problems as well as problems in the choice of metals for fabrication of the various parts of the plant. These problems are becoming more acute as the specifications of the produced resins become more and more stringent. The color characteristics of resins as well as certain other physical and chemical properties have been demonstrated to be due to certain functions, which may vary for any particular resin, such as: the presence of local overheating of the resin in the resin-manufacturing kettle; the length of time taken to get the batch of raw products up to temperature; the time given to refluxing and to dehydration; the rate of reaction and the temperature at which the reaction takes place; the presence of air in the manufacturing kettle and the extent to which the same is whipped into the resin-producing reactants. The factors in the design of resin plants which have the most to do with bringing each of the above named functions within control are numberless.

Mixer units for resin kettles

The problem of selecting the means of agitation for a resin kettle is probably the most important in effecting proper rates of heat transfer, in preventing local-overheating and in maintaining adequate contact between the reacting materials. The problem is further complicated in the manufacture of those resins which require that a blanket of CO_2 be laid as a preventative against oxidation of the resin. The several types of agitators which have found use in resin kettles include paddles, propellers, turbines, horseshoes and various combinations such as paddle and horseshoe, and turbine and horseshoe.

Scraped resin kettles

Resin manufacturers know what good insulators their materials are. During processing when heated they stick to the heating surface and insulate the rest of the batch, the part remaining stagnant next to the heating surface being in turn locally overheated. Of course with thermal-setting resins this local overheating results in the formation of a hard film or deposit which must be removed before the next batch can be made. Similarly, when cooling resins the part of the batch which thickens from contact with the cooling surface offers resistance to the cooling of the rest of the batch, sometimes with the result that cooling is so retarded that the product does not have the desired characteristics. Kettles made with the single-motion positive-scraping agitator require a minimum of cleaning or chipping between batches. (See Fig. 29.)

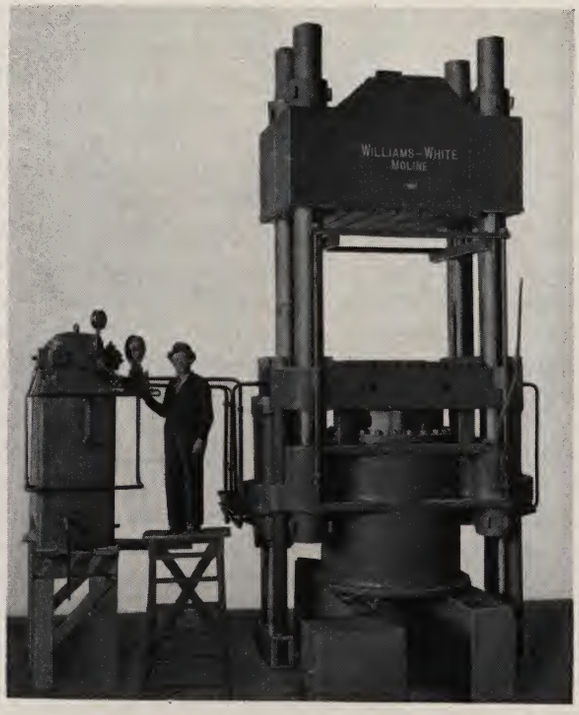
It has been reported that with positive-scraping 9 percent more usable resin is made and that 14 percent more distillate is collected. Kettles of this class are cast-in-one-piece, copper-free nickel-chromium-iron alloy containing 17 percent to 20 percent nickel. The agitator is made of 18-8 stainless steel.

The kettle which makes possible the mechanical scraping, down to the bare metal, is of cast seamless jacketed construction. It might be cheaper to use a kettle fabricated of ordinary steel, stainless steel, nickel-clad steel, etc., but because of temperature changes such a fabricated kettle will warp out of round, after which its agitator will not properly scrape it. A cast kettle stays true because of its one-piece cast reinforced construction, with the result that its agitator continues to positively scrape its wall all of the way around. These kettles have considerably reduced manual cleaning.

Resin thermocouples

As an aid to good kettle operation and because of the small amount of space available for a temperature device at the bottom of a positive-scraping mixer, especially designed thermocouples have been developed. The type which is successful for chemicals, greases and soaps, has exposed wires which would not withstand chipping off of material solidifying on it, such as thermal setting resins, so a special resin thermocouple was developed. This operates on the same general principle—that of dissipating jacket heat before

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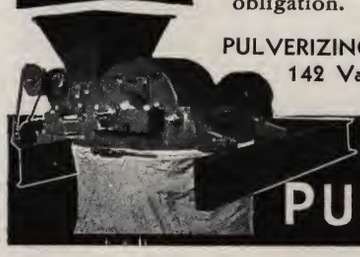
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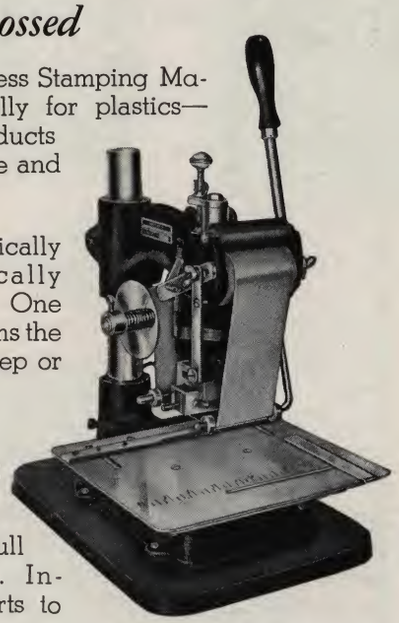


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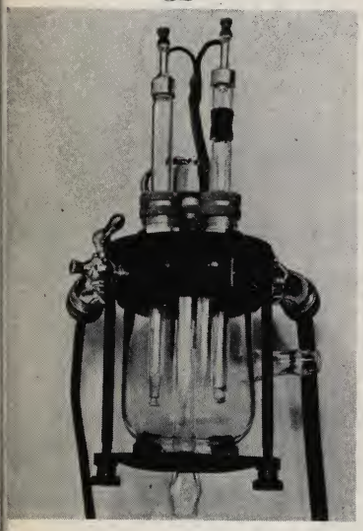
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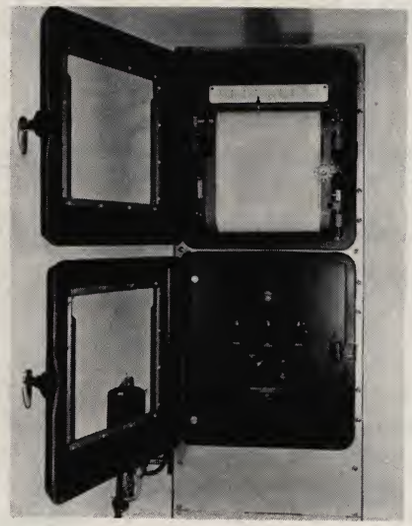


31—Baker-Perkins mixing and kneading machine for rolling resinous and cellulosic compounds. Has single stuffing box to maintain high vacuum. 32—Electrode cell of recording type pH meter. It may be used for either flow or dip type of application. 33—The complete pH meter recorder assembly. Made by Cambridge Instrument Co.

32



33



it reaches the junction of the thermocouple wires so that this junction gives the temperature of the batch of resin. (See Fig. 30.)

A $^3/_8$ in. O.D. tube of stainless steel encloses the thermocouple wires which are joined at a closed tip. Being perfectly smooth, the tube can easily have adhering resin chipped off between batches. It is located near the bottom of the kettle and projects into the kettle about $1^1/_2$ in. Agitators are slotted to clear its projection and to continually bring new parts of the batch in contact with it. The thermocouple, because of its construction, is reported by users to give substantially the true temperature of the resin being processed, regardless of the temperature of the kettle jacket through which it is installed.

31 Heating and cooling of resin kettles

Methods of heating kettles include direct firing of the kettle by gas or oil burners, by the encasing of the kettle with electrical resistance units, steam, hot oil-circulating systems, and Dowtherm units, the individual chosen unit being determined by the fire hazard involved, municipal ordinances and the temperatures involved. Where direct firing of the kettle is contemplated by the designer, liberal allowances in plate thicknesses above that required to withstand any collapsing or other type of pressure should be made to take care of temperature-difference stresses encountered in the metal and of losses in tensile of the metal involved with continuous firing of the kettle. In such cases, and especially where the resin involved is sensitive to local overheating, the flames of the burner should be applied to the estimated center of maximum turbulence in the kettle. For fairly obvious mechanical reasons flames should never be played upon the bottoms of flat-bottom kettles. In particular, such kettles because of the dead-spots created at the seam, create the greatest danger of local overheating when so heated.

Electrical heating units applied to the outside wall of the kettle have had a fairly common usage, and are vastly superior to direct-firing methods in that the heating is more uniformly distributed. The expense of installation of such units as well as the difficulty of arranging for efficient cooling of the charge either by air or other means where resin processes involve not only an initial heating of the batch to temperature but also a subsequent period of removing of the heat of reaction, have combined to speak against such units. There are, however, a fair number of cases of electrical heating of an immersion bath which itself was used to heat the kettle and where cooling coils running through the bath provided the means of cooling when required. The problem involved here is too straightforward to demand treatment.

Regarding jacketed kettles, regardless of whether the same are used for steam, circulating oil or Dowtherm, the following considerations have been proved to be helpful in the design of same. The advantage obtained by its use is the restriction in the passage of the heating vapors to that portion of the kettle in direct contact with the charge during the heating-up period, while during the dehydration period as well as during the refluxing period the vapors may be heated in the one case, assisting in dehydration, and cooled in the other case, thus reducing the burden on the condenser. In larger units, two or more sections may be used to accommodate various batch sizes. Care must be taken, however, in providing return lines with adequate valving controls to that the falling off of pressure in any single portion of the jacket, during the continuance of normal pressure in any other portion of the jacket will not result in the sucking up of condensate into any single portion of the jacket thus possibly creating a dangerous lowering of the liquid level in the boiler, regardless of type. Despite the additional cost of the split type of jacket, the advantages in operation indicated above will more than compensate for increased expenditure.

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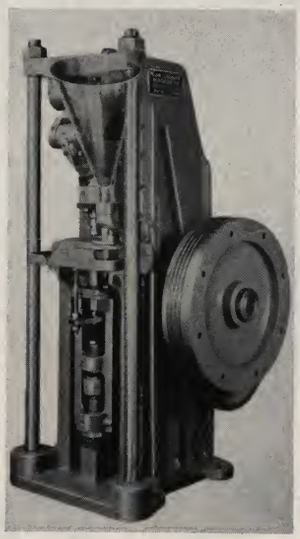
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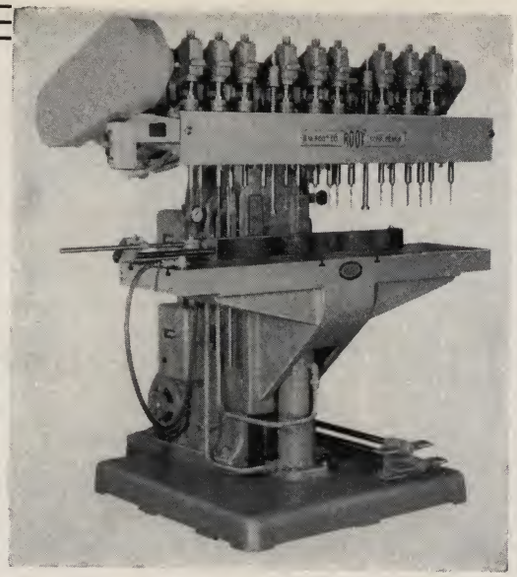
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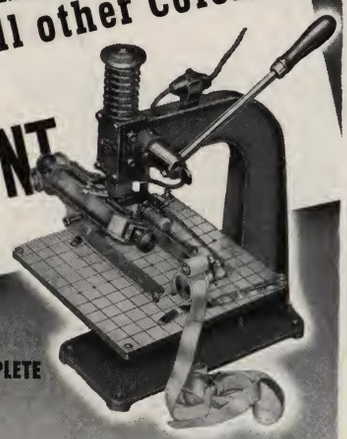
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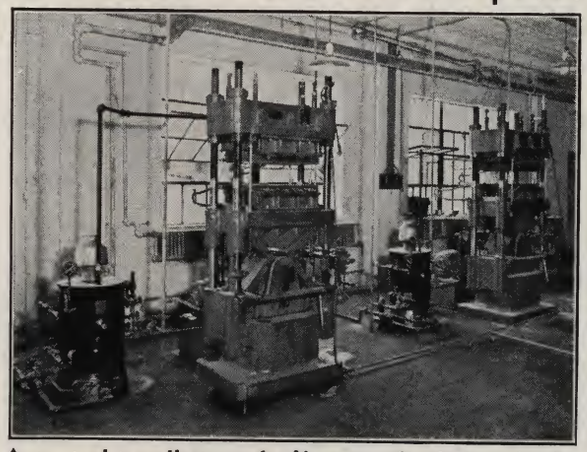
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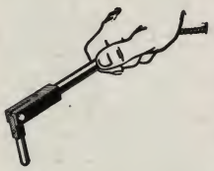
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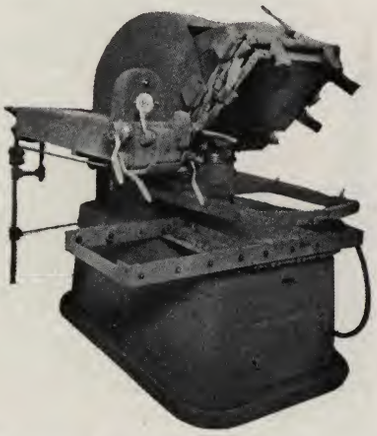
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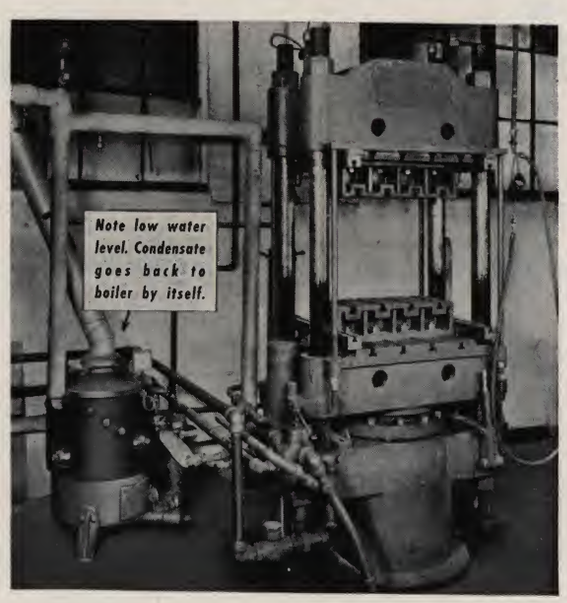


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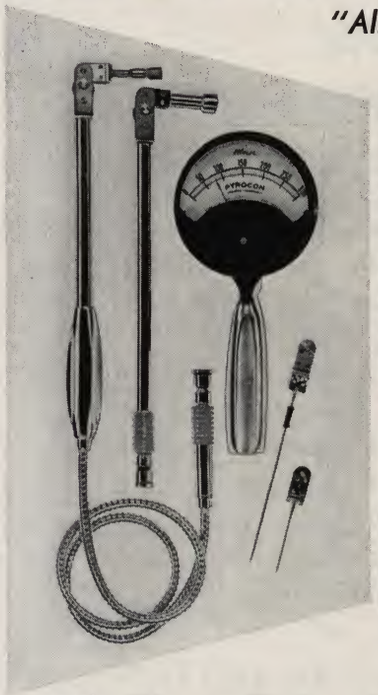
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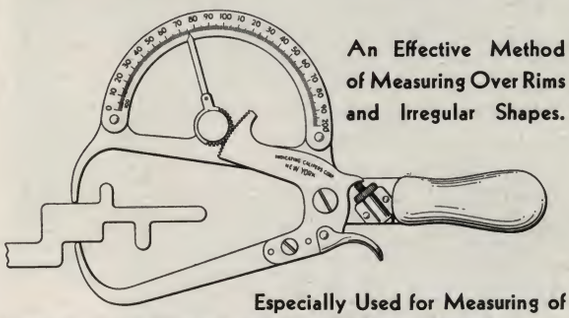
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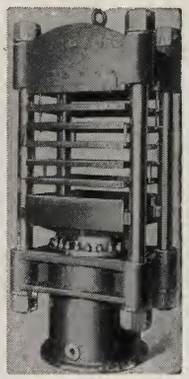
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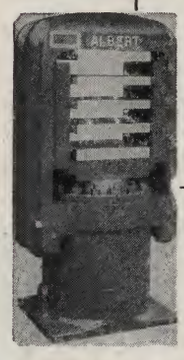
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Additional copies of the Solvents Chart (opposite page 426), Plasticizers Chart (opposite page 446) and the Plastics Properties Chart (opposite page 150) may be purchased from the publisher.

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MODERN PLASTICS
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LAMINATES

Pages 389 to 424

Flow sheet—390

Manufacture of laminates—392

Fillers for laminates—394

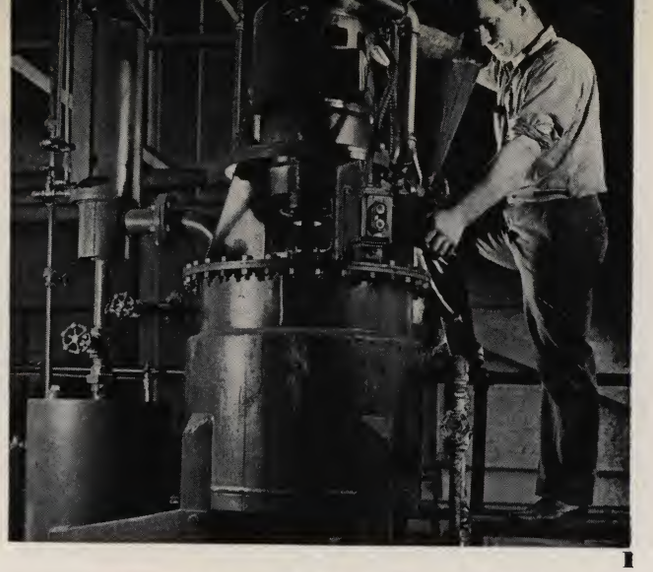
Decorative laminates—396

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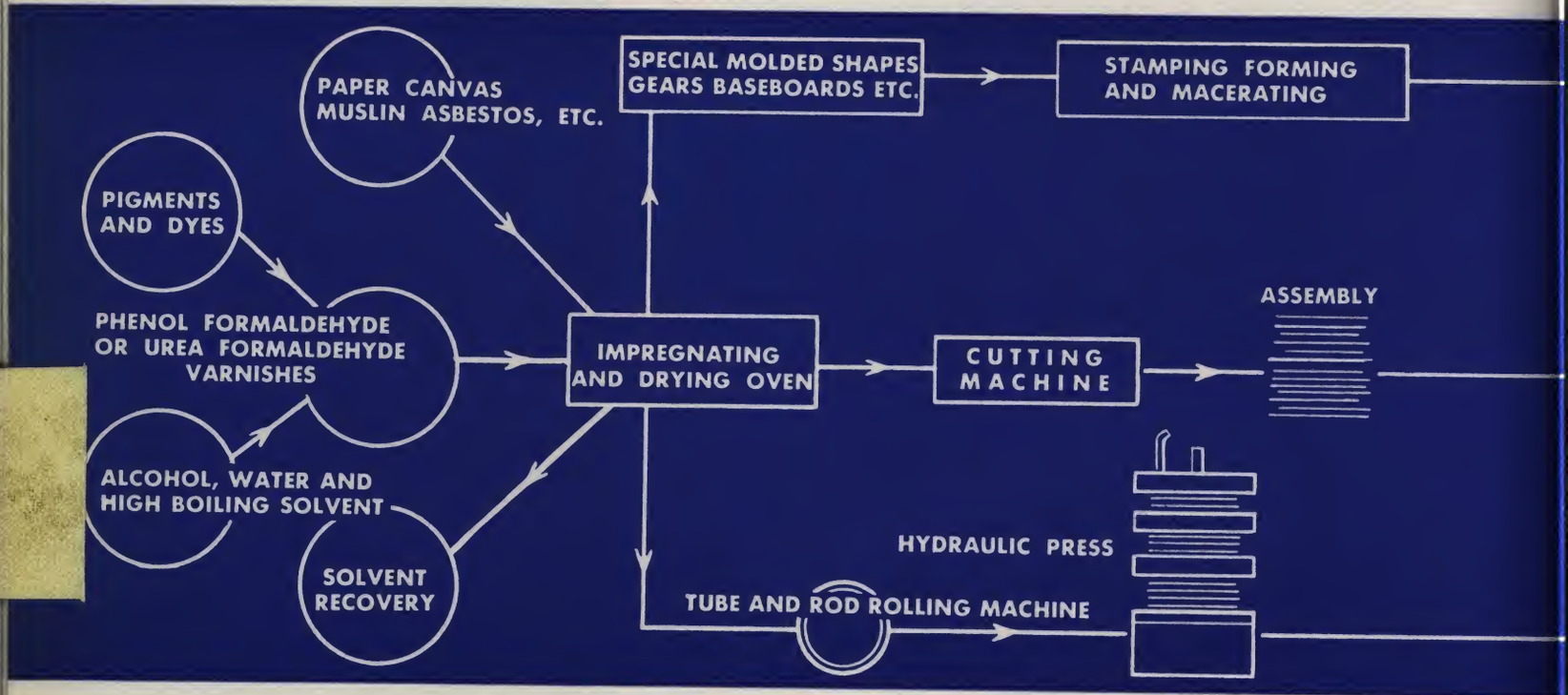
Laminates



1

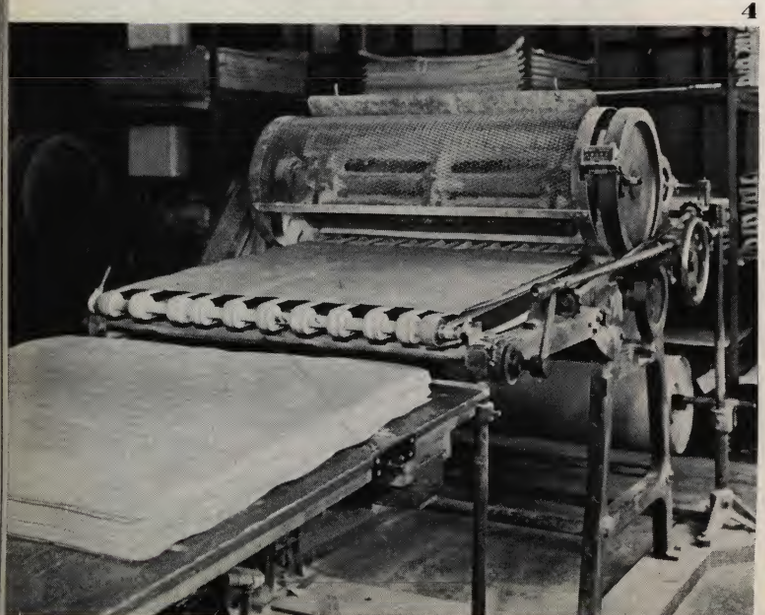
1—Reaction kettle where the resin is thinned to a consistency that will permit its saturating the paper or cloth filler material. Thinning is done by introducing in the kettle a liquid solvent

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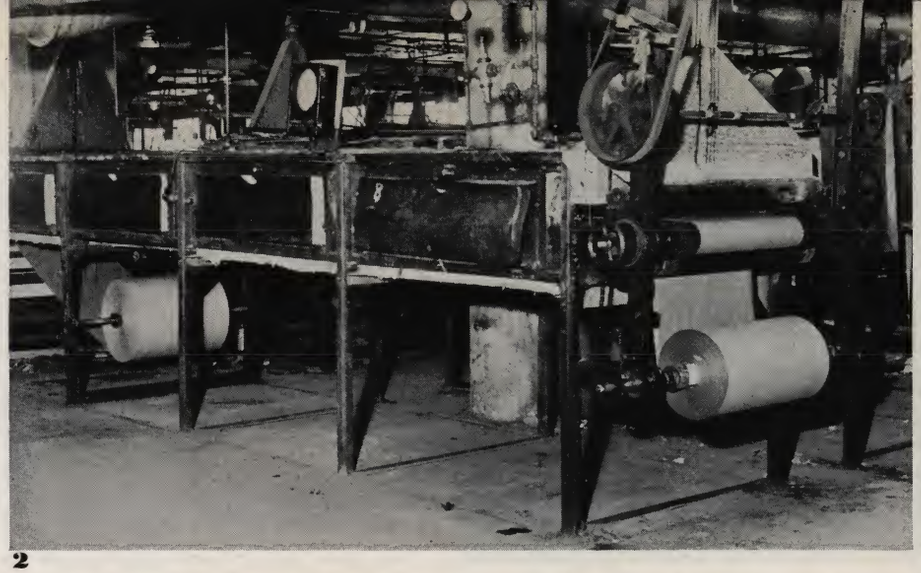
4—Impregnated paper is cut into sheets on rotary cutters. 5—The sheets are assembled for laminating between polished steel plates, preparatory to curing under pressure. The surface sheets may contain color, printed designs or inlays for decorative applications

4



5



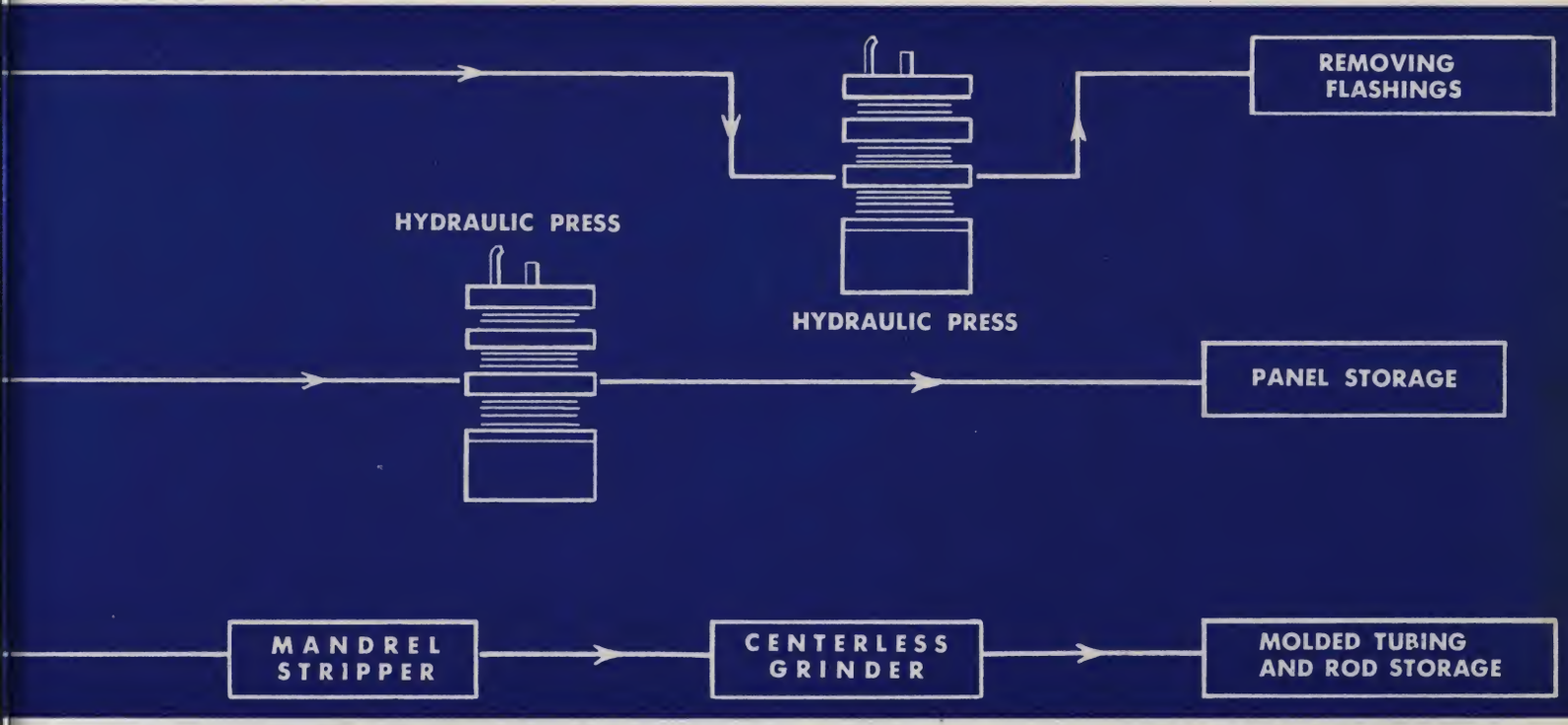


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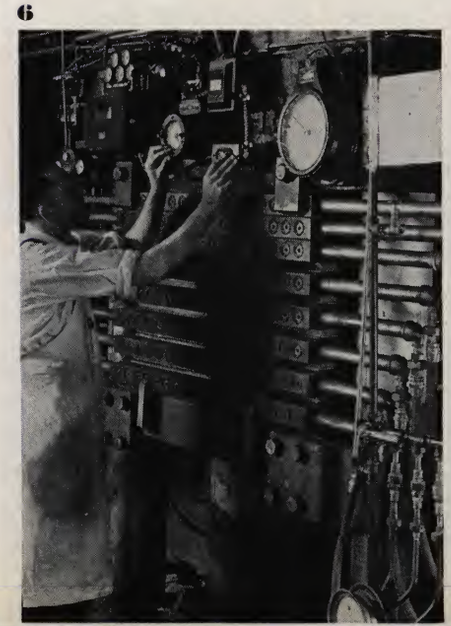
3

2—Raw paper in 100 to 1000 pound rolls in widths of three, four, or eight feet, is fed at carefully controlled speeds into the vertical, horizontal, or camel-back treating ovens where the resin solutions are absorbed, the solvents evaporated, and the impregnated paper rolled up again.
3—A view of the towers used in recovering the solvents from the treated papers or fabrics



6—The treated sheets of paper are compacted and cured in hydraulic presses. **7**—Laminated material tubes and rods are prepared by winding the treated material onto a mandrel. **8**—The rolled material is heated between platens to produce tubes and rods which are ground and buffed to exact size required.

6

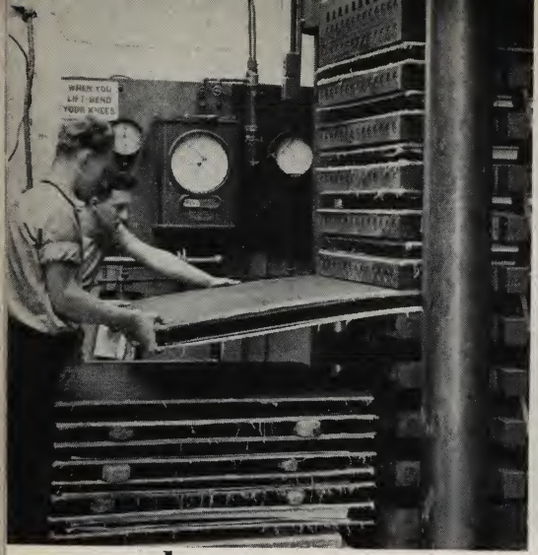


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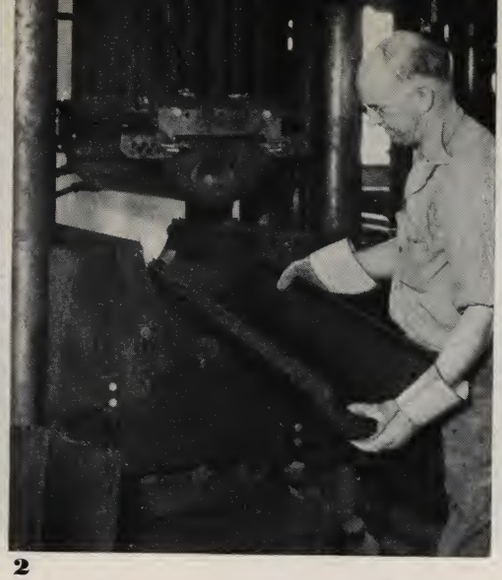


8





1



2

1—Oriented cellulose and other type fillers are impregnated with urea and phenolic resins, subjected to heat and pressure in a multiple platen press. 2—Laminated roll neck bearing of resin-treated fibers are pressed in a half-round mold (All Photos, courtesy Mica Insulator Corp., General Electric Co. and Synthane Corp.)

Manufacture of laminates

LAMINATED plastics are made from resins combined with fibrous sheets such as paper, cotton fabric and asbestos, the combination being consolidated into plate form by the simultaneous application of heat and pressure. Other materials such as glass fabric, wood or even thin fish paper are often incorporated in the process. The resins are used in the form of solutions in solvents such as alcohol or water and are limited largely to phenol- and urea-formaldehydes; the first soluble generally in alcohol and the second in water.

If the paper, fabric or asbestos filler material is dipped in these varnishes and then subjected to moderate heat, the solvents pass off as vapor leaving the paper impregnated with essentially dry resin. The process is not quite as simple as it sounds. Actually the resin passes from what is known as "Stage A" to "Stage B" in this process and a partial polymerization has taken place. The degree of cure or drying of the filler necessary for good laminating properties varies with the grade of material required, and the quality of the finished sheet, tube, or rod, is dependent upon the care exercised in the maintaining of uniform drying conditions which have been previously determined as best for the grade under consideration. It is possible to make sheets of pure resin but they have no commercial value because they are too brittle to handle, much less to use. The filler serves two purposes then, first to add the strength and flexibility factors to the finished product and second, to prevent the resin impregnated in the paper from squirting out of the press as it passes through the liquid stage under heat.

Impregnating

Although vertical impregnating machines are successfully operated in some plants, horizontal impregnating machines are more widely employed. A roll of paper or fabric is placed beneath the front end of the machine on a mandrel. As it unwinds, the paper or fabric passes over a guide roll, dips down into the resin solution, continues up over another guide roll where a plate or a squeeze roll either scrapes or squeezes off excess varnish, then the paper or fabric disappears into the machine. The interior of the machine is fitted with steam coils and as the paper runs through, the heat throws off the alcohol in the varnish and dries the coated material to the proper degree. As the coated material leaves this oven and is wound on a convenient mandrel, it has a resin content varying from 20 percent to 70 or 80 percent depending upon the kind of material that is being made. The proper degree of dryness for each grade of material is determined by a test of "volatile content." This may vary from 1 to 6 percent depending upon the standards of temperature and drying time. If too dry, the resulting material will be brittle and show poor lamination. If on the other hand the coated material is too green, the excess resin flow may cause crushing and flow out of the press. Therefore, the coated material is not completely dried since this operation would carry the polymerization too far and prevent satisfactory lamination. Some laminators recover the evaporated solvent by cooling and condensing the exhaust vapors or by passing them through activated charcoal. (See also pages 394–5)

Color, printed designs and inlays

To provide a colored surface in the finished sheet, a pigment coat is put on the color sheet. The coloring consists of a mixture of suitable pigments in urea resin varnish. Paper or fabric previously treated with urea varnish to give it strength is dipped in the solution, coated on but one side and passed through the oven for drying. The material then has a urea back and urea color on top. If a translucent rather than an opaque product is desired, the pigment is omitted and dyes are used for color effects.

Laminated material embodying printed designs, such

as wood grains, instrument panel layouts, wiring diagrams, dials, and the like, is secured by printing. Designs are etched on the surface of a continuous copper plate wound around a cylinder which contacts the inked printing roll and subsequently transfers the design on the paper. It required years to work out suitable inks to do this job because there must be nothing in them that is foreign to the consolidation process. No laminated material is printed with ordinary types of lithographing inks. The printing rolls themselves had to be specially developed for this purpose. Printers use gelatin rolls but these are not practical for laminated printing since the urea inks are water soluble.

Many table tops, doors, panels, counter fronts and tops and other decorative or architectural applications are inlaid with metal strips or contrasting colors of other laminated materials. These strips, or any inlays, are laid on the surface to form the desired pattern and then are actually pressed down into the sheet to a point where they are absolutely level with the surface. Two or more colors may be introduced into the decoration and many variations are possible. Lettering may be easily incorporated into the design but complicated patterns are inclined to boost the cost.

Assembly for pressing

All these steps are preliminary to the actual laminating process. Each careful step of preparing the sheets is carried on separately in various departments, then they are finally brought to the assembly room where they are collated for pressing. (See page 390–391)

The surface of the laminated sheet is determined by a steel plate which for a glossy finish has a mirror surface. For a satin finish, a satin-surfaced plate is used. Likewise, Morocco and other leather finishes are obtained from a steel plate in which this finish has been carefully engraved. There must be no pits, dents, scratches or anything else in these plates, for the least little scratch will show up in the material. Even the most minute defect on the plate will repeat itself in the laminated surface. The finish obtained can only be as good as the plate from which it is pressed.

In building up a decorative sheet, a translucent urea sheet is placed against the finish plate, followed by a printed sheet which has its decoration on the front. Next comes the color background sheet, blister-proof sheet (if one is being used), filler stock and the backing sheet. If a plain colored sheet is desired, then the printed sheet is omitted. If actual wood is being laminated, the impregnated veneer supplants both the printed and color background sheets.

When all this is pressed together it results in a $^1/_{16}$ in. sheet of finished material. Two sheets may be built back to back with no plate between to get two $^1/_{16}$ in. sheets. Six sheets are normally built up in one pack and seven packs are cured at one time in the press which gives a capacity of 42 sheets at one pressing, although this may vary considerably from one plant to another.

A typical press takes a full length pack, making sheets 3 ft. by 8 ft. under a total pressure in excess of 5 million pounds. The total curing time varies, but from the moment the pack is placed in the press until it is removed requires about two hours for urea material. The maximum temperature is approximately 270 deg. F. Phenolic material cures in less time. All material has to be completely cooled in the press because a certain volatile content remains even in the finished sheets. If the pressure is relieved at high temperature, the volatile in liquid form, flushes into vapor and blisters the sheet. Each batch, therefore, is cooled under pressure by water circulated throughout the press platens which are channeled for this purpose as well as for steam which is used to heat them. A cooling tower is provided outside the building to constantly reduce the water temperature while the presses are operating.

Buffing

No matter how efficiently the laminated sheets are handled, minute scratches always appear which must be buffed out. This is done on a machine which accommodates a full size sheet and requires about two minutes to refinish the entire surface, using cloth buffs running at 3600 r.p.m. These buffs are about 24 in. in diameter. The operator holds the sheet, running half of it into the buff, then turning it around, the other half is buffed in the same way. Sometimes there are local areas in a sheet which require local hand buffing and the ease with which this is accomplished indicates a good simple method for repairing damages in the surface of table tops or other applications, should they occur.

The final result of the impregnating and curing operations is a dense, uniform material, permanently nonfusible and insoluble, possessing outstanding mechanical and electrical properties, and capable of being fabricated into products for many industrial and decorative uses.

3—Assembly of sheets prior to laminating requires cautious procedure. All steel finishing plates must be handled with meticulous care, and placed in position manually. 4—Band saw cutting round form from laminated stock. Additional machining follows for producing required gear mesh or other forms

3



4



Fillers for laminates

THE laminating division of the plastics industry is unique in that all types of materials produced contain fillers in one form or another. The compression or injection molder may or may not use filled materials depending on the type of resin which he is molding but the base of the laminating industry is the filler onto which the resin or varnish is applied.

In general, three types of filler are used in producing the numerous grades or finishes of laminated products. Papers, cotton fabrics and asbestos are used in various forms to produce a wide variety of properties in the finished materials. Each of these fillers will be discussed.

Paper fillers

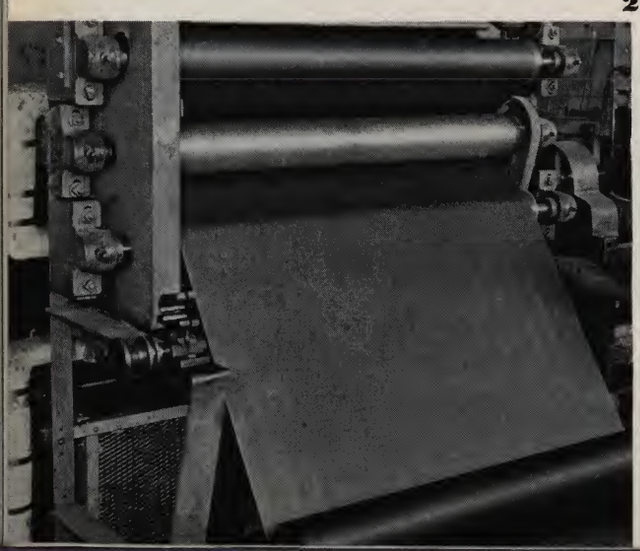
The majority of papers used in laminating are divided into two classes; namely, rag and wood fiber. In the beginning of the laminating industry, rag papers were thought to be necessary for the production of a good laminated sheet and, due to the nature of wood fiber papers being made 20 years ago, this statement was essentially true. Rag papers do not deteriorate under heat, they have good absorbency for varnishes and are likely to be uniform in quality. In recent times the high price of rag fiber papers has led to the development of a variety of wood fiber materials which are suitable for laminating purposes. The best quality of wood fiber papers are the so-called "alpha cellulose." In many respects this type of paper is equal to rag paper and there is usually an improvement over rag paper from the standpoint of cleanliness. The sulphites are being used by laminators to a certain extent. Kraft papers in the bleached and unbleached form are used where high strength, paper base, laminated products are required for mechanical applications.

There are some properties which must apply to all types of paper used in laminating work. The weight per unit of area must be uniform not only across the width of the sheet but also from the beginning to the end of the original rolls. The thickness must be carefully controlled in the same manner. The relationship of these two requirements has a decided effect on the rate at which a paper will absorb the impregnating varnish and changing the relationship of these two may seriously effect the quality of the final product. The uniformity of the formation of the paper is highly desired. Excessive *wildness* may result in unimpregnated fiber bundles. The finish of the paper used has an effect on the bonding strength of the laminated material; a highly finished paper may actually cause a delamination of the assembly under some punching conditions. Care-

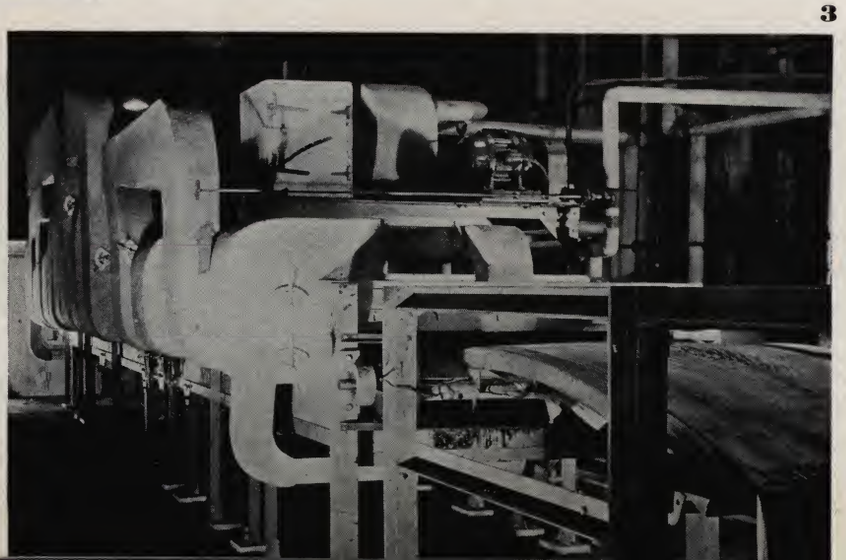
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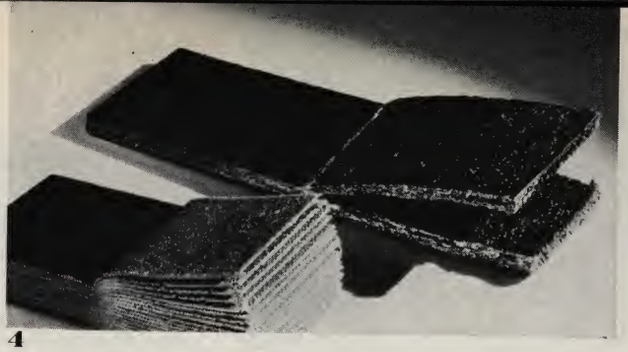


3



1—Raw paper in 100 to 1000 lb. rolls are fed at controlled speeds into immersing baths of liquid resin. 2—Phenolic impregnated paper issuing from machines which evaporate solvent after dipping in liquid resin and which roll up the saturated paper. 3—Large machine for impregnating and drying long rolls of canvas materials. (Photos, courtesy Westinghouse Electric & Mfg. Co., Mica Insulator Corp., General Electric Company)

4—Resin treated sheets shown before and after pressing. 5—Typical laminated shapes—rods, sheets and tubes



4



5

ful control of the acidity or alkalinity of the paper must be maintained in order that the curing characteristics of the varnish will not be effected.

The selection of a particular type of paper is usually determined by the ultimate application of the finished, laminated material. A particular paper may be chosen from a standpoint of cleanliness which will give clarity to a finished translucent sheet or from the standpoint of absorbency which will give electrical characteristics or punching qualities to the finished sheet. Tensile and flexural strength of finished laminated material is largely dependent on the strength of the paper from which it is made.

Papers for laminated products are usually the natural color of the fiber although some papers are filled with white or brown pigments to give opacity when used as surface sheets. Black papers are used to a certain extent where the finished material is likely to be machined and show exposed fibrous surfaces.

The types of papers used vary for different purposes in both decorative and industrial laminates and cost anywhere from five cents up to twenty-three or twenty-four cents a pound. Almost every type of paper is used including some straight rag papers for extra strength.

Cotton fabric fillers

Cotton fabrics used in the laminating industry generally will run from 2 oz. per sq. yd. to 16 oz. per sq. yd. but, for special applications such as bearings, fabrics up to 40 ounces per sq. yd. have been employed. Light-weight fabrics such as are used in making the so-called Grade L in the laminating industry weigh 4 oz. or less per square yard. The minimum thread count per inch for this type of material is 72 in the filler direction and 140 total in both warp and filler direction. Standard print cloths, sheeting and lawns are ordinarily used for this type of product. So-called Grade C which is made up with a fabric base weighing more than 4 oz. per sq. yd. may be made from a variety of fabrics. Heavy sheetings are occasionally used where good machining is required in the ultimate product. For gears which may be either molded to size or band sawed from sheet stock, heavier fabric such as army duck, osnaburgs or flat ducks, single filling or double type, may be used.

Usually fabrics are used in the gray state although for applications where cleanliness of appearance or especially good machining characteristics are required, the fabric may be desized or bleached. In the same manner as paper is chosen to meet a certain condition, so fabrics are chosen to meet similar conditions in the finished laminated product.

The choice of a particular fabric may depend on the strength required in the finished product or the type of varnish with which the material is to be impregnated. The sizing content of any given fabric may influence the water resistance and strength or machining properties of the material. When fabric base materials are used for electrical applications, extreme care must be taken to insure the selection of a fabric which will not affect the curing characteristics of the impregnating varnish. In the choice of one fabric over another, the impact resistance of the finished material may be a deciding factor.

The types of fabric used for industrial purposes vary from a 3 ounce per square yard up to a 16 ounce per square yard and cost anywhere from 25 cents per pound up to 75 or 80 cents per pound.

Asbestos paper and fabric fillers

There is an increase in volume of asbestos filler materials being used by the laminating industry. Asbestos paper is used as a filler where heat resistance is of prime importance. Ordinarily this type of material is made up with varnishes which will withstand higher temperatures than those used in connection with paper or cotton fabric.

The most moisture resistant laminated material produced is made with asbestos cloth filler. In general, the so-called underwriters' grade or Grade AA asbestos fabrics are used because these grades contain more pure asbestos than the commercial asbestos cloth. As a result of using the better grades of asbestos cloth, there is less dimensional change within the finished products when they are used in contact with water. The laminating industry has been responsible for the development of a square woven type of asbestos cloth which gives a more uniform strength in the two directions of the laminated sheet.

Other fillers

Undoubtedly there are many other types of filler which will eventually be used by the laminating industry which have not yet found commercial applications. Among these are such materials as manila mat, genuine wood, felted cotton fabric and Fiberglas. To date, no extensive use has been made of any of these materials as fillers; either because of their lack of availability, high cost or limited properties of the finished material.

Unquestionably there are other fillers which will impart specific characteristics to laminated materials which cannot be obtained in any other manner. When the demand for these characteristics becomes sufficient to justify the cost of the same, we will probably see a considerable expansion of the laminated field along lines entirely different from those followed at the present time.



1



2

1—Formica inlaid fluorescent laminated sheet material made with light reactive chemicals produces a highly decorative, luminous panel for the Farragut Theatre. They are especially appropriate for theatres, clubs and public building corridors, in dark or semi-dark places. 2—Plasdecor laminate bonded with Beetle resins incorporates in it any decorative motif—textiles, paintings, mosaics. Designed by Alice Donaldson and laminated by General Electric Company

Decorative laminates

SHEETS of paper or fabric impregnated with phenolic or urea resins with colored surface laminations, which are sometimes printed in wood, marble or other designs, and cured together under heat and pressure, are known as decorative laminates.

Inlays are made in the sheets by cutting a design of one color out of treated but uncured sheets and laying it over a background of another color. A number of colors may be combined in this way. Or the design may be cut from metal foil and laid on a colored background sheet. When the sheet is cured these designs become an integral part of the sheet.

Some sheets are also made by using an actual thin veneer of wood either woven or plain as the figured lamination. This is impregnated with resinoid in the usual way and has provided decorators with combinations of rare woods in which the surface life has been infinitely lengthened and improved.

Characteristics of the material

The material has a hard smooth surface and great depth of color. These give it an appearance which is unique among decorative materials and never obtainable before. The surface may be very high gloss if the original finish obtained from curing against a highly burnished metal sheet is allowed to remain. It may be a satin finish if the original high gloss is rubbed with pumice, or it may be a Morocco or grained surface if the metal sheet against which it is cured has been engraved with a figure.

Light colors with a high degree of stability can be produced by careful selection of pigments and by the use of urea resins which maintain their clear white translucency under the effects of sunlight. Phenolic resins, on the other hand, turn yellow under the effects of the sun and sheets where the surface laminations are treated with this resinoid are not particularly stable in color but are inclined to turn somewhat yellow as they age in use.

Decorative laminates are harder than marble and will stand a great deal of wear. They are inert chemically—among the most inert of materials with an organic origin—and therefore will not spot with fruit acids, alcohol or other solvents, or milk alkalies. If a lamination of metal with high heat conductivity is incorporated just under the surface, it will spread the heat from a lighted cigaret or cigar so rapidly that the material becomes completely resistant to burning cigarets. This will not, however, prevent the blistering of the material if a high degree of heat is applied over a large area, as in that case the volume of heat exceeds the capacity of the metal lamination to conduct it away and damage may result.

3



3—Dinette table by Kompass & Stoll has a colorful stain- and spot-proof Formica top. Decorative edge is of the same material installed as an insert to match or contrast with the top surface

WHAT MATERIAL?



Let

Continental-Diamond

Manufacturing Experience and Laboratory Research

Help You Find the Answer

ALMOST every day you face the problem of meeting changing standards of product performance. You must devise new and better ways of manufacturing procedure and *find materials suited to meet these changes*. That's where the Continental-Diamond Research Laboratory can help you. Continental-Diamond materials are versatile. As a result of our laboratory research and manufacturing control we can vary individual properties to meet exacting requirements.

Many special materials developed by the C-D Laboratory have become almost standard because of the rapid advances made in all industries toward more efficient and more economical product performance. To mention a few; first, C-D VULCOID, a material combining to a remarkable degree the desirable properties of both vulcanized fibre and phenol fibre; then C-D DIAMOND-DILECTO, developed to combine the greater arc resistance of vulcanized fibre with the moisture resistance of phenol fibre; and C-D DILECTO NAME PLATE STOCK, a white core black surface sheet material, which when engraved exposes the white core for striking and effective contrast and permanent name plates.

To meet the constantly changing and more exacting demands of all industries the Continental-Diamond Laboratory carries on relentless research, trial and experiment. Its files contain thousands of case histories of what at the time seemed insurmountable problems. This wealth of information and the experience and knowledge gained in solving these problems may be of invaluable help to you. Do, as many of our customers have done for years, use our research laboratory as though it were part of your own organization.

SEND FOR THIS BOOKLET!

Just off the press. It includes a quick reference chart that will help you determine the best material to use based on two primary needs. It also gives complete data on standard sizes, colors and finishes of C-D materials. Your designers, buyers and engineers will find it indispensable. Ask for Booklet G-6. Write today!

CONTINENTAL-DIAMOND FIBRE CO., NEWARK, DEL.

C-D Products

DILECTO—A laminated plastic possessing unusual electrical insulating, mechanical and moisture resistance properties.

VULCOID—A laminated resinous fibre combining to a high degree the desirable properties of laminated phenolic and vulcanized fibre.

DIAMOND vulcanized FIBRE—A tough, hard, bone-like material of high dielectric and great mechanical strength.

MICABOND—Mica in its most usable form—sheets, tubes, segments, rings, punched and formed parts.

CELLULAK—A specially laminated tubing with high dielectric strength and extreme resistance to flashover.

CELORON—A molded phenolic fabric base plastic of exceptional mechanical strength, attractive appearance, light weight and great stability.

Properties of translucent laminates

Translucent laminates possess many desirable properties which have opened up a wide field for the material in applications where heat softening materials and glass were formerly used. The excellent mechanical strength allows the use of thinner sheets thus permitting lighter weight designs. The coefficient of expansion is comparable to other types of laminated phenolic products and moisture absorption after 24 hrs.' immersion is under 5 percent.

Translucent laminates, being thermohardening plastics, are conceded to be more brittle than the thermoplastic type of material. The sheets are sufficiently flexible to bend cold into small radii in the lesser thicknesses and when heated to approximately 250 deg. F. to 300 deg. F. can be formed in simple shapes such as cylinders, half cylinders, S curves, etc.

Further, it may be noted that these laminates are:

1. Uniform in translucency and coloring
2. Non-inflammable and heat-resistant
3. Non-shatterable
4. Resistant to warping or shrinking
5. Easily machined and punched

Recent developments

One of the important developments during the year on decorative laminates has been the adoption by a large number of furniture manufacturers of the material for dinette tops.

Another application which has made great progress during the year and is now either being used or being considered by practically all manufacturers of domestic refrigerators is the use of the material on refrigerator door backs; that is, covering the entire back surface of a refrigerator door with laminated material. In some cases white urea surface sheets are used and in others black material, either in the form of flat sheet or a molded door back is lacquered for the desired color.

Another interesting development during the year was production of fluorescent laminates. An inlaid fluorescent laminated sheet material has been made for the display and decorative field. When regular white light is turned off and ultraviolet "black" light is turned on, inlaid figures of various designs glow in a variety of beautiful color effects. The fluorescent effect is produced by chemicals which have the property of converting the invisible ultraviolet light into visible light. The effect is different from phosphorescence in that it stops immediately when the ultraviolet irradiation is stopped. The effect is more pronounced when shown in the dark—a semi-lighted room gives proportionately less effect. The rays of the H4 ultraviolet light are said to have no harmful effect on skin or eyes. The fluorescent colors, the company reports, are not as light-stable as regular pigment colors and are not recommended in direct exposure to the sun.

The vending-machine industry has made extensive use of translucent laminates, particularly for the coin-operated phonographs which are illuminated during operation. Interesting and effective types of illumination have been worked out to attract attention to these machines. Large sheets of laminated plastic not only add color variety and translucency not possible with wood or metal, but help to reduce weight and consequently, shipping costs.

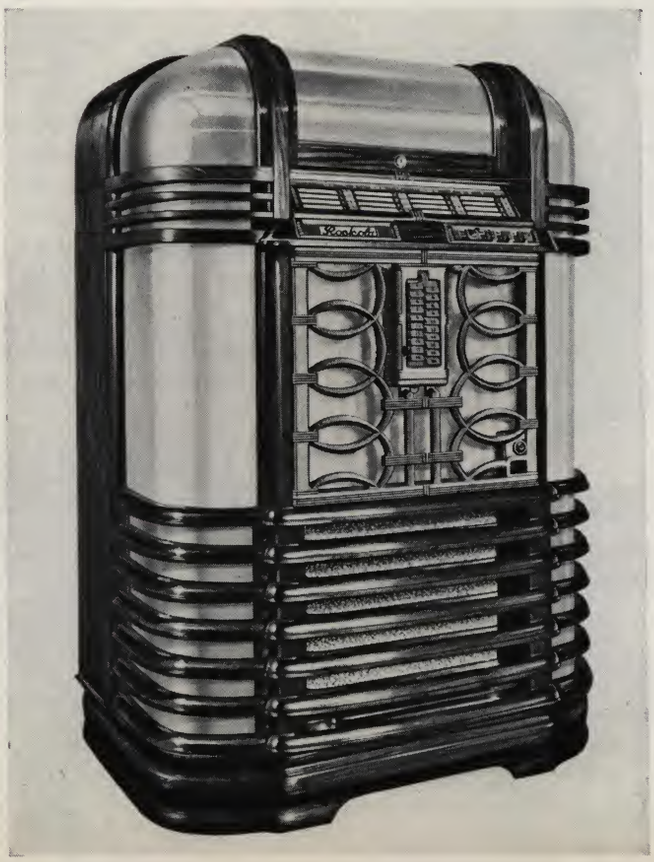
Translucent laminates have a large and constantly increasing number of applications for decorative, lighting and utilitarian purposes in the advertising, mer-

4—Ceiling of Roumanian Restaurant Lounge at World's Fair formed from thin gage translucent Lamicoid panels provides a soft, mellow light. 5—Rockola automatic coin phonograph with attractively decorated front of translucent Insurok. Cabinet lights up while playing for an eye-catching effect. Cast phenolic ornamentation adds to the cabinet's attractiveness

4



5



FORMICA

FOR MANY USES IN INDUSTRY!

ELECTRICAL INSULATION



Many different grades of Formica sheets, tubes and rods are made to suit various electrical requirements. From these fundamental shapes parts of all varieties are fabricated to the users' blueprints.

POWER DISTRIBUTION



In distribution systems for electricity, Formica is used for panel boards, circuit breaker barriers, bus bar insulation, tubular insulation and also machined parts for terminals.

RADIO INSULATING PARTS



In radio, sheet stock and punched parts are used for tube bases in receiving and transmitting sets as well as for terminal strips, sub-panels and similar uses. Plain and threaded tubing is used for inductances.

X-RAY & THERAPEUTIC DEVICES



X-Ray material is carefully produced in the Formica factory to avoid opaque spots when used for cassett covers. It is also used for bucky diaphragms and instrument panels. Tubing is used as a conduit for leads on X-Ray machines.

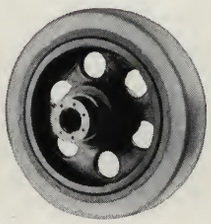
AVIATION

Manufacturers of airplanes use Formica control pulleys, Fairlead bushings and machined parts, where lightness, strength and stability of dimensions are required. These parts are constantly tested under Army and Navy specifications.



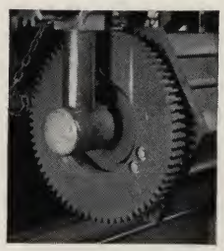
TRUCK TIRES

Non-metallic, floor-saving tires for factory trucks are available in Formica. Because of their chemical inertness they are used in chemical plants where other tires can't stand up.



CHEMICAL INDUSTRIES

The chemical inertness of Formica makes it suitable for many uses in equipment for handling chemicals. It is unaffected by petroleum and is used for pump vanes and valves in refineries. There are special grades to resist both acids and alkalies.



DECORATIVE SURFACES

Formica decorative sheet is made in many colors and patterns and is used for table tops because it will not spot, stain, or crack. Its smooth surfaces make it ideal for inspection tables in textile mills.



- The Formica factory at Cincinnati is one of the largest units in its industry and in addition to manufacturing equipment has a large installation of fabricating machinery so that buyers who wish to get parts finished and ready for assembly can have them machined to their blue prints. Ask for the Formica data book.

THE FORMICA INSULATION CO., 4615 SPRING GROVE AVE., CINCINNATI, O.



6



7

6—Parkwood - Textolite, woven-wood veneer laminate, serves a useful purpose when used for construction and also for equipment as shown in office of Dr. W. L. McKenzie. Desk and cabinet surfaced with the material are unaffected by acids moisture, alcohol or oils

chandising, electrical and industrial fields. They are particularly applicable to lighting fixtures, signs, displays and illuminated architecture.

Translucent laminates when first introduced were principally used for radio dials. Since that time manufacturers of instruments requiring dials in other fields have adopted this type of material principally because of its inertness and non-corrosive properties. Plastic dials have replaced metal in many applications involving adverse atmospheric conditions, chiefly because of the non-corrosive properties of the material. Sheets or pieces of varying thicknesses (0.010 to 0.063 in. being those in most common use) in dimensions up to 36 in. by 42 in. formed into ovals, cylinders, half-rounds or flats, permit uses that would be impractical with other materials. Applications utilizing silk screen or rubber plate printing directly on the translucent plate produce extraordinary effects for illuminated advertising displays.

A new and expanding commercial field has been opened by the introduction of a sheet in which the body of the laminate is opacified, retaining the translucent surfaces under which any sort of printed graphic matter may be permanently embodied.

Exhibitors and concessionaires at the New York World's Fair and the Golden Gate International Exposition made extensive use of translucent laminates for advertising, architectural, decorative and lighting purposes in both indoor and outdoor applications.

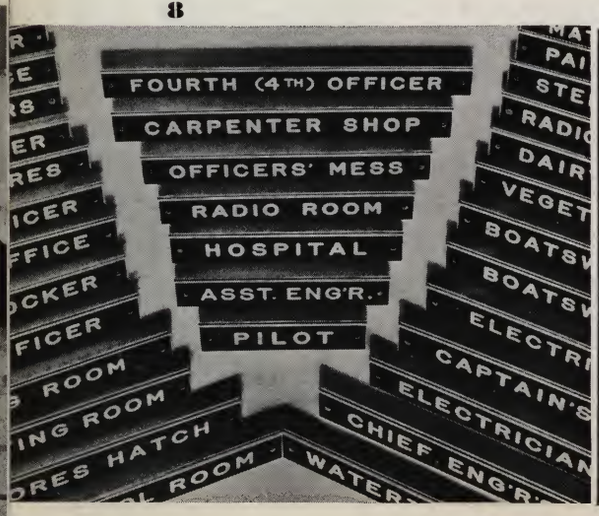
One of the markets where decorative laminates are finding an extensive outlet is for parts of coin-operated machines of various kinds. They have served for years on many of the mechanical parts. While "juke" boxes aren't accepted as parlor furniture they are important to many roadside restauranteurs scattered over the length and breadth of the land. As these coin-operated devices came into more popular use the demand to make them colorful and attractive was a corollary to their expanding sales function. The attractive shades available in both opaque and translucent laminates with their desirable sturdy, stable, structural characteristics made them ideally suited materials and as a result they ear now being even more extensively employed as standard material for that growing industry.

Forms available

Decorative laminates are available in the form of $^1/_{16}$ in. veneer sheets which are glued to plywood in a veneer press with casein glue to produce table tops, counter tops, counter panels, wall panels, doors and similar structural parts of fixtures and buildings. (*Please turn to page 405*)

8—Easily read Lamicoid signs for designating departments on board ship are made by using a white core, then engraving through a black outerlayer for striking impressive contrast. 9—Reid Murdock Co. Lion trademark is realistically reproduced in Insurok. This urea-formaldehyde laminated outdoor sign has splendid weathering qualities

8



9



TEXTOLITE LAMINATED

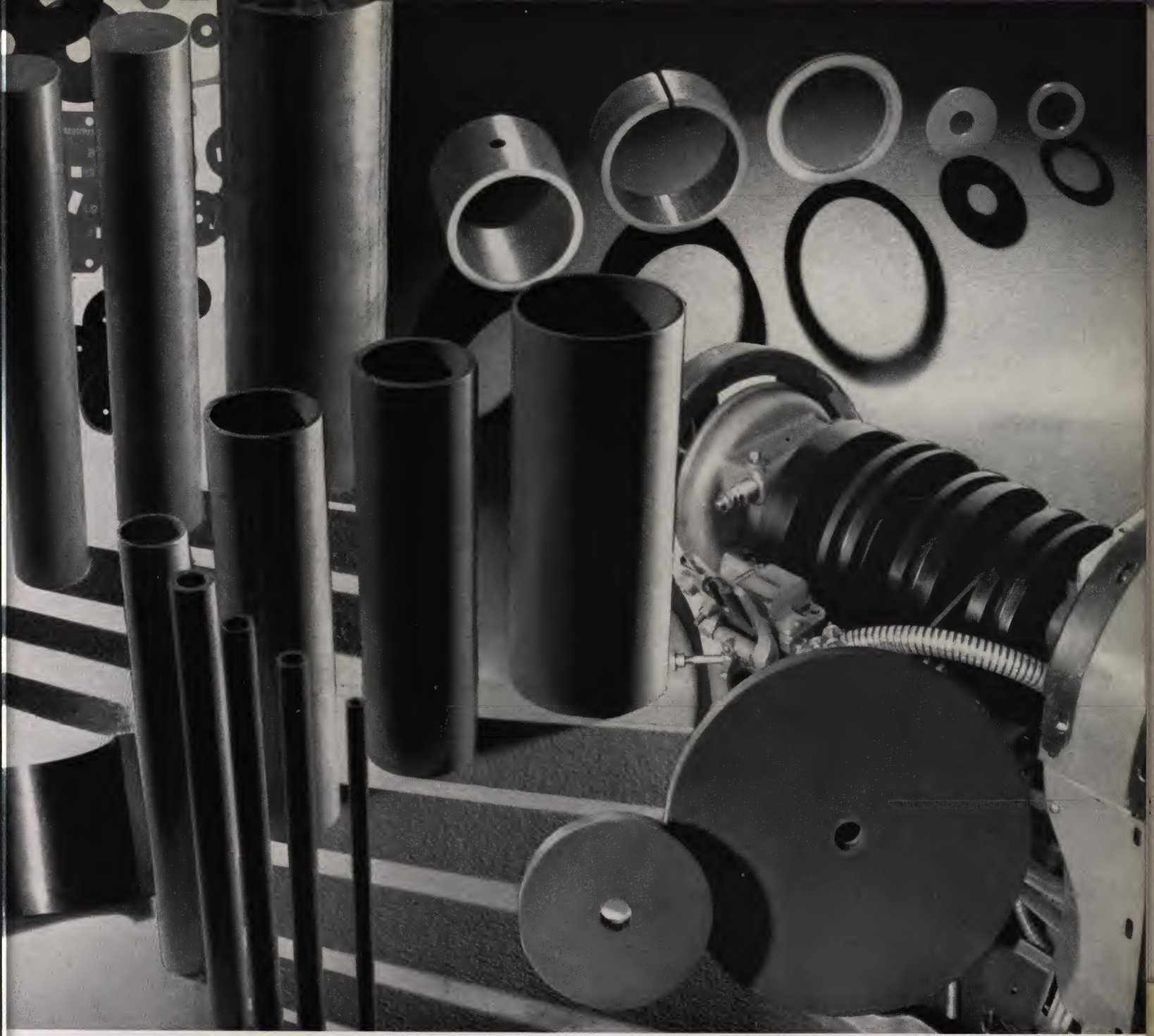
SHEETS • RODS • TUBES • GEARS • BEARINGS • FABRICATED PARTS



SERVING INDUSTRY IN ITS CONSTANT EFFORT

Industry's constant effort to manufacture better products at a lower cost has been a vital stimulant to the use of laminated Textolite . . . Originally a material providing electrical insulation, Textolite now serves the mechanical fields to an equal degree and its applications have grown with amazing rapidity . . . As an insulator, Textolite long ago entered the electrical manufacturing and radio industries to serve as control panels and insulation in electrical apparatus; as coil forms, tube sockets, band switches and the

Plastics



TO MAKE BETTER PRODUCTS AT LOWER COST

like in radios . . . Its mechanical properties—its toughness, resiliency, strength, durability and machinability make it applicable for bearings, gears, cams, and structural supports, and its uses for these applications are legion . . . Textolite laminated is made from 50 different formulations, each constructed to specific requirements, so that the material can be accurately and efficiently fabricated by sawing, stripping, drilling, shearing, punching, slotting or bevelling.

GENERAL ELECTRIC

PLANTS

Pittsfield, Mass.—One Plastics Avenue
River Works—920 Western Ave., West Lynn, Mass.
Meriden, Conn.—34 Cambridge Street
Fort Wayne, Ind.—1635 Broadway

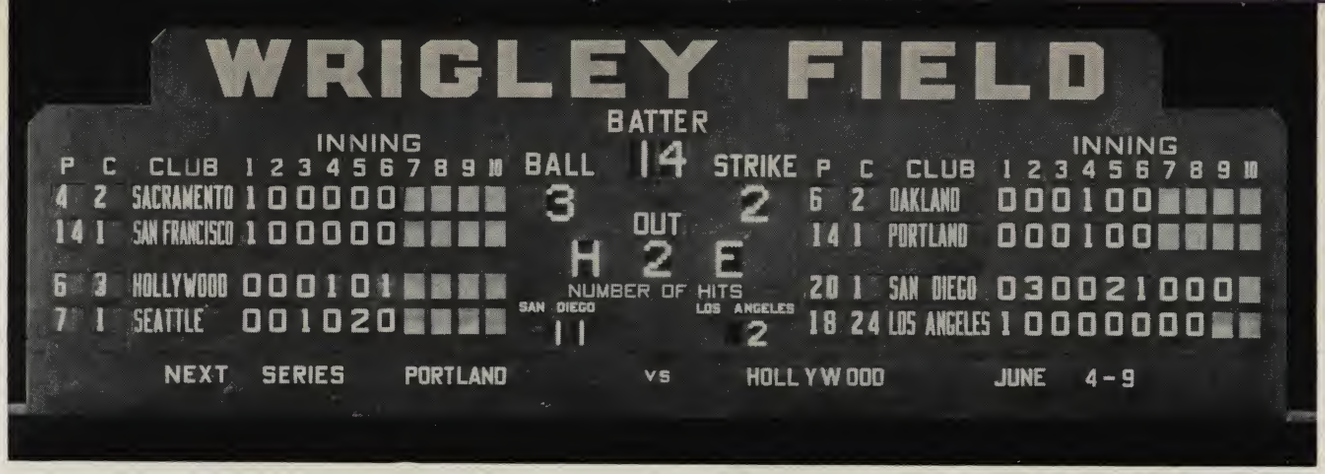
OFFICES

920 Western Ave., West Lynn, Mass.
34 Cambridge St., Meriden, Conn.
570 Lexington Ave., New York, N. Y.
1405 Locust St., Philadelphia, Pa.
4966 Woodland Ave., Cleveland, O.
700 Antoinette St., Detroit, Mich.
230 South Clark St., Chicago, Ill.
89 East Avenue, Rochester, N. Y.
1635 Broadway, Ft. Wayne, Ind.

PLASTICS DEPARTMENT

GENERAL ELECTRIC

PB-414



10

10—Brilliant night or day legibility on this mammoth Wrigley Field scoreboard made by Newbery Electric Corp. is secured through translucent Lamicoid sheet. Movable figures and letters were made by painting dark areas with opaque colors

Decorative laminates are also available in a sheet of which the center is a highly compressed fiber board, the total assembly being from $^{5}/_{32}$ to $^{11}/_{32}$ in. thick for erection against wood grounds or wood backing as a wall board. They are available also in steel-center sheets. There are a few molded shapes for use as baseboards, window sills and cover molds between sheets of wall covering.

Translucent sheets are made by treating all the laminations with urea resins. These may have opaque surfaces so that the opaque surface sheet may be sand-blasted away to form designs through which light will shine. If pigment is added to the center sheets treated with urea, there is produced a white or colored center sheet with an opaque body and opaque surface in a different color. When the opaque surface sheet is engraved away, lettering or designs may appear in white or other light colors.

It is possible also to print lettering and designs on finished decorative laminated sheets in bronze inks by an offset process. These inks are usually mixed with phenolic resinoids and after printing the panel is baked to cure the varnish in the ink, producing a very hard and durable form of lettering. Panels may also be engraved and the engraved lettering or designs filled with gold or silver. The sheets may be hot stamped with the lettering or designs likewise filled with white gold or silver.

Typical applications

Furniture tops
Wall covering
Doors
Elevator cab interiors
Inlaid mural designs
Telephone booths
Counter tops and paneling
Refrigerator door backs
Back bars
Translucent lighting fixture
Translucent signs and displays
Instruments and other dials
Translucent Venetian blinds
Architectural lighting
Coin-operated machines

Outstanding Properties

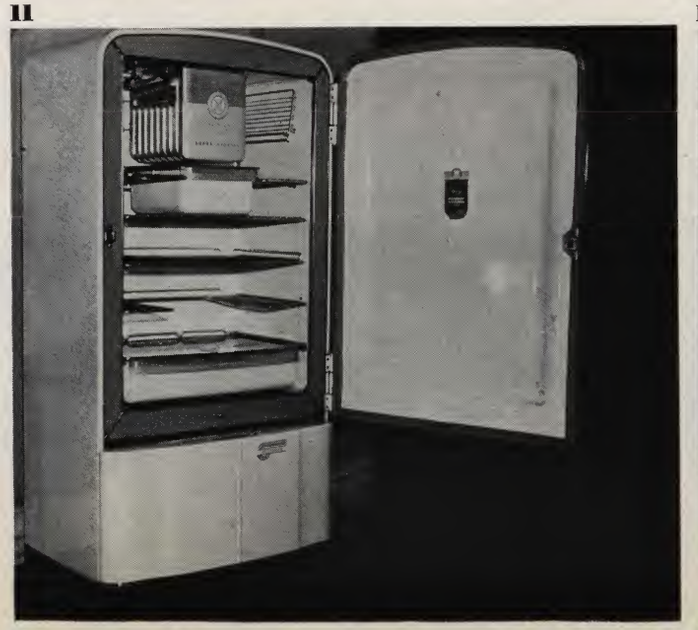
Depth of color
Durability
Resistance to stains and cigaret burns
Beauty of surface
Chemical inertness
Translucency in some grades
Resistance to spotting or discoloration

Trade names

Dilecto, *Formica*, *Insurok*, *Micarta*, *Lamicoid*, *Panelyte*, *Parkwood-Textolite*.

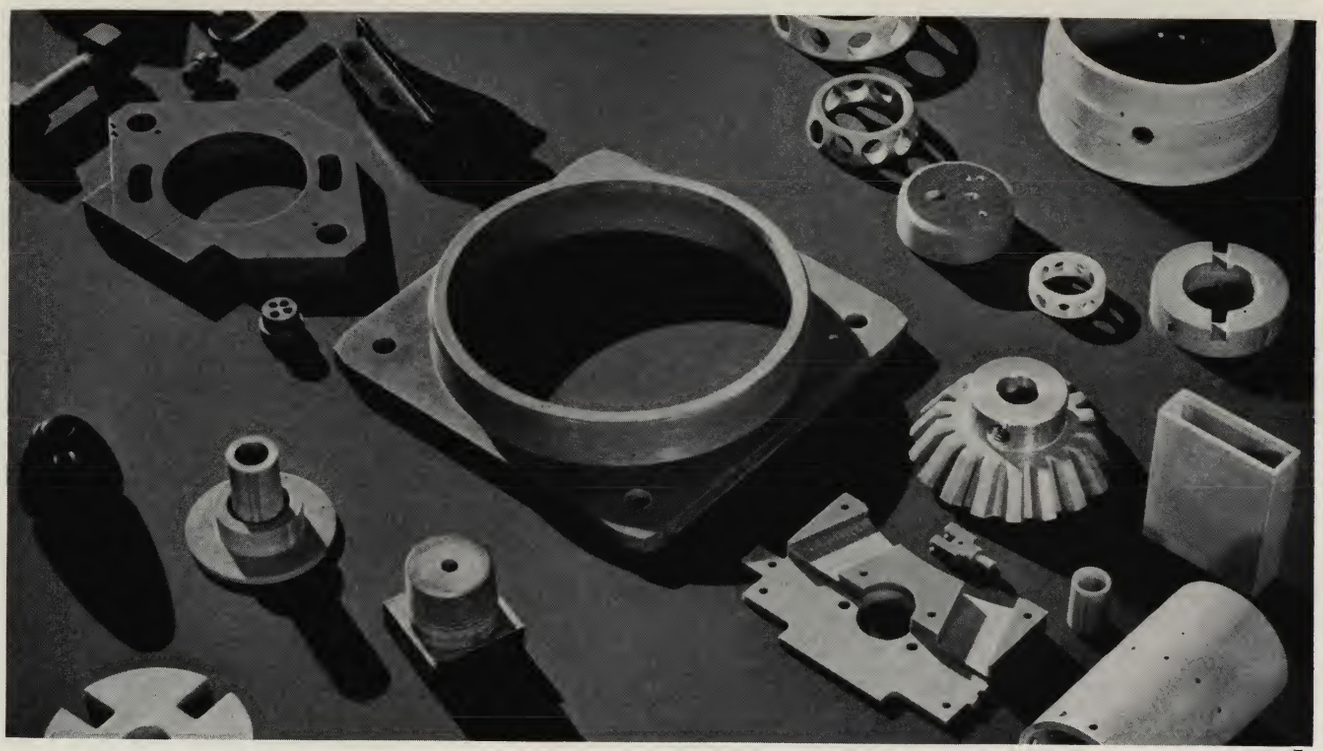
11—Refrigerator door liners of laminated Micarta. Urea-formaldehyde used for impregnating the fiber base, provides an integral, easy-to-clean, chip-proof surface. 12—Serviceable Formica Realwood serves for the wainscot, the window trim, the baseboard, the counter panels and the counter tops in Hagerstown, Md.'s new city hall. Taylor and Fisher architects, A. J. Klinkhorst, associate

11



12





1

1—Miscellaneous laminated parts, including gears, cams, gaskets, insulators, tubes, bushings, coils, valve seats, rack joints, of high mechanical and dielectric strength, are intricately fabricated, drilled, turned, bored, milled, sanded, buffed, ready for use. (Photo, courtesy Synthane Corp.)

Industrial laminates

ONE of the first uses of synthetic phenolic resin was as a binder in making phenolic laminated materials for electrical insulation purposes. Before this new material had progressed very far in the insulation field, it was tried experimentally in making non-metallic gears for quiet operation and found satisfactory. From this point on, phenolic laminated materials have been used more and more extensively for industrial applications.

Phenolic laminated materials are divided mainly into two classes—paper and cotton fabric base. Asbestos fillers are being used on applications requiring high heat resistance. Each of these two classes is divided into a number of grades, developed to meet the specific requirements of industrial and electrical applications. There are three general forms, plates, rods and tubes, from which are machined the required parts for specific uses. A fourth form, simple molded shapes, with relatively uniform cross section thickness to simplify molding, is economical on large production items, where the machining operation to produce these parts from standard plates, rods or tubes is a major item of cost. Also the material can be placed in the mold to give maximum directional strength. This cannot always be accomplished on machined parts. On molded parts the finish is uniform and pleasing and does not require special refinishing operations.

Laminated material has several predominant characteristics that collectively make it an ideal material for many uses. These advantages are as follows:

1. High ratio of strength to weight
2. Resiliency or low modulus of elasticity
3. Lightness in weight
4. Resistance to corrosion
5. Will not score or adhere to metal
6. Properties are permanent at normal humidities and temperatures
7. Low heat conductivity
8. Machinability

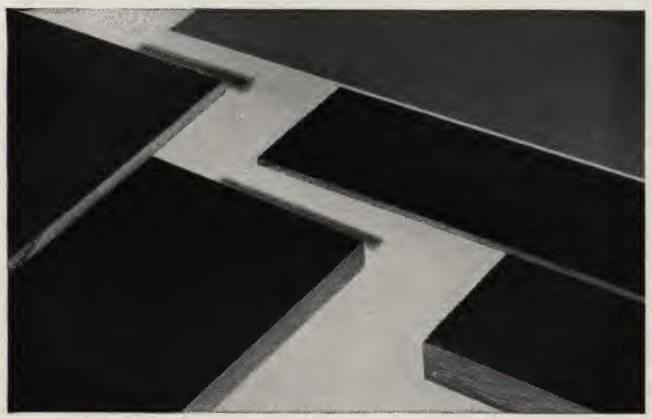
As previously mentioned, laminated paper materials were first tried industrially as non-metallic gears for quiet operation. This type of gear was so successful in minimizing noise that other installations were made. However, these failed by stripping the teeth in a few days. It was realized that a stronger or tougher material was needed for impact load, and cotton fabric was

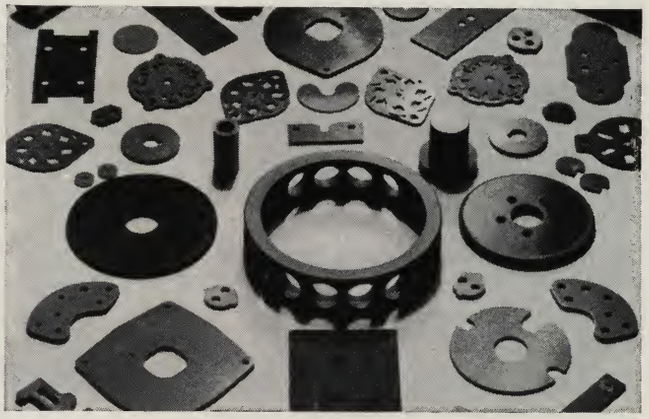
TAYLOR FIBRE COMPANY

Manufacturers of Vulcanized Fibre, Phenol Fibre, Taylor Insulation, Taylor Silent Gears

NORRISTOWN, PENNSYLVANIA

CHICAGO, ILL., 11 S. Desplaines St.
CLEVELAND, OHIO, 1213 W. 3rd Street
DETROIT, MICH., 6432 Cass Avenue
MANCHESTER, CONN.
MILWAUKEE, WIS., 1560 W. Pierce St.
NEW YORK CITY, N. Y., 90 West St.
PHILADELPHIA, PA., 708 Provident Trust Building
PITTSBURGH, PA., 235 Oliver Avenue
ROCHESTER, NEW YORK, 82 St. Paul Street
SAN FRANCISCO, CAL., 218 Howard Street
ST. LOUIS, MO., 2127 Pine Street
ST. PAUL, MINN., 503 Pioneer Bldg.
TORONTO, ONT., 409 Metropolitan Building





TAYLOR VULCANIZED FIBRE

TAYLOR Fibre is an exceptionally high-grade vulcanized fibre, produced with particular attention to the specific requirements of fibre users for convenience and economy in fabrication, and for great mechanical strength and high insulating qualities.

The superior properties of this vulcanized fibre are due to the modern methods of manufacture which are employed in a new, up-to-the-minute plant where specially designed machinery, highly refined raw materials, sparkling clear artesian well water and corrosion-resisting equipment and piping throughout, produce the "cleanest" sheet of fibre that can be procured.

Taylor Vulcanized Fibre is offered in all standard colors and in thicknesses from .005 inch to 2 inches.

Taylor Fibre sheets over ⅜″ and up to 2 inches in thickness are supplied in a special waterproof grade which has general qualities of both vulcanized fibre and phenol fibre. Prices of this fibre are the same as the regular vulcanized fibre list.

TAYLOR INSULATION (Fish Paper)

Taylor Insulation, made by the same improved methods and equipment as Taylor Vulcanized Fibre, possesses the same superior mechanical and dielectric properties. Taylor insulation is supplied in all practical thicknesses and in either sheets (60″ × 90″) or continuous rolls (60″ wide). A new standard for armature insulation and other electrical work where a thin, extremely flexible yet strong insulation of high efficiency is required.

TAYLOR PHENOL FIBRE

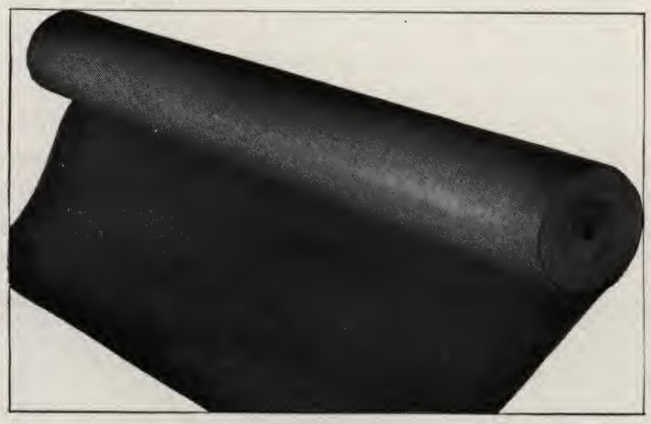
Taylor Phenol Fibre is a phenolic resin—impregnated paper or fabric formed with heat under hydraulic pressure into sheets of high dielectric strength, great physical strength, low moisture absorption, unaffected by heat or cold (excepting extremely high temperatures) and resistant to oil and most chemicals.

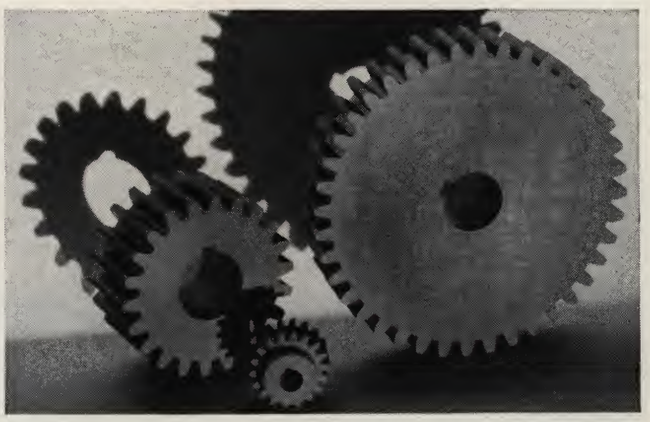
Because this material is readily machined, it is adaptable to modern high speed production methods. It answers the specifications of a majority of insulating problems with properties which in many cases exceed N.E.M.A. standards. Made in all standard thicknesses from .005 to 10″. Supplied in standard colors.

TAYLOR SILENT GEARS

Taylor silent gear blank stock is a highly resilient, wear-resisting phenol fabric of great strength and durability. In quieting noisy metal-to-metal contacts in the gear trains of many types of machines. Taylor silent gears absorb shocks, save wear, reduce the hazard of breakdowns and costly production delays, save maintenance expense, improve the quiet operation and lengthen the life of not only the gear trains but the machines themselves. Taylor Silent Gear material, made from a woven fabric impregnated with phenolic resin and formed under high pressure into an extremely dense substance, withstands contact with chemicals, dust, dirt, grit, grease, oil and rodents.

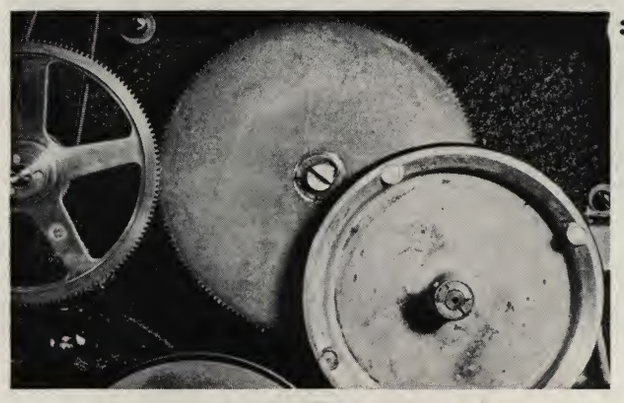
It may be accurately and easily machined, and being less affected by heat and cold than even metal itself, it remains accurate on the job.







2



3



4

2—Laminated plastic trim tabs for use on ailerons, elevators and rudders of airplanes are light, strong, unaffected by moisture, corrosion-proof and rapidly produced. Unfinished tab at top shows molding details. Developed for Glenn L. Martin Co. by Formica Insulation Co. and Taylor Fibre Co. 3—Non-resonant laminated Textolite is used by General Electric for the idler gear in the Movie Mite sound movie projector. 4—In the coin-operated J. H. Keeney & Co. anti-aircraft gun game, laminated Insurok for cams, multi-plug, ratchet wheel and socket structure is used in the operating mechanism. (Photos, courtesy Richardson Co.)

selected to give this toughness. Gears made this way were entirely satisfactory and today are used universally where quiet and smooth operation is of importance.

To cover the complete range of gear sizes, materials have been developed, using a fine woven, cotton fabric, for electric clock gears and a coarse, cotton canvas fabric for industrial gears, as large as 5 ft. in diameter, with a possible face of 10 inches. Most gear teeth are machined from blanks, cut from plates or molded to size. However, some, mostly bevel gears for light duty where tooth accuracy is not necessary, are molded from laminated or mascerated fabric.

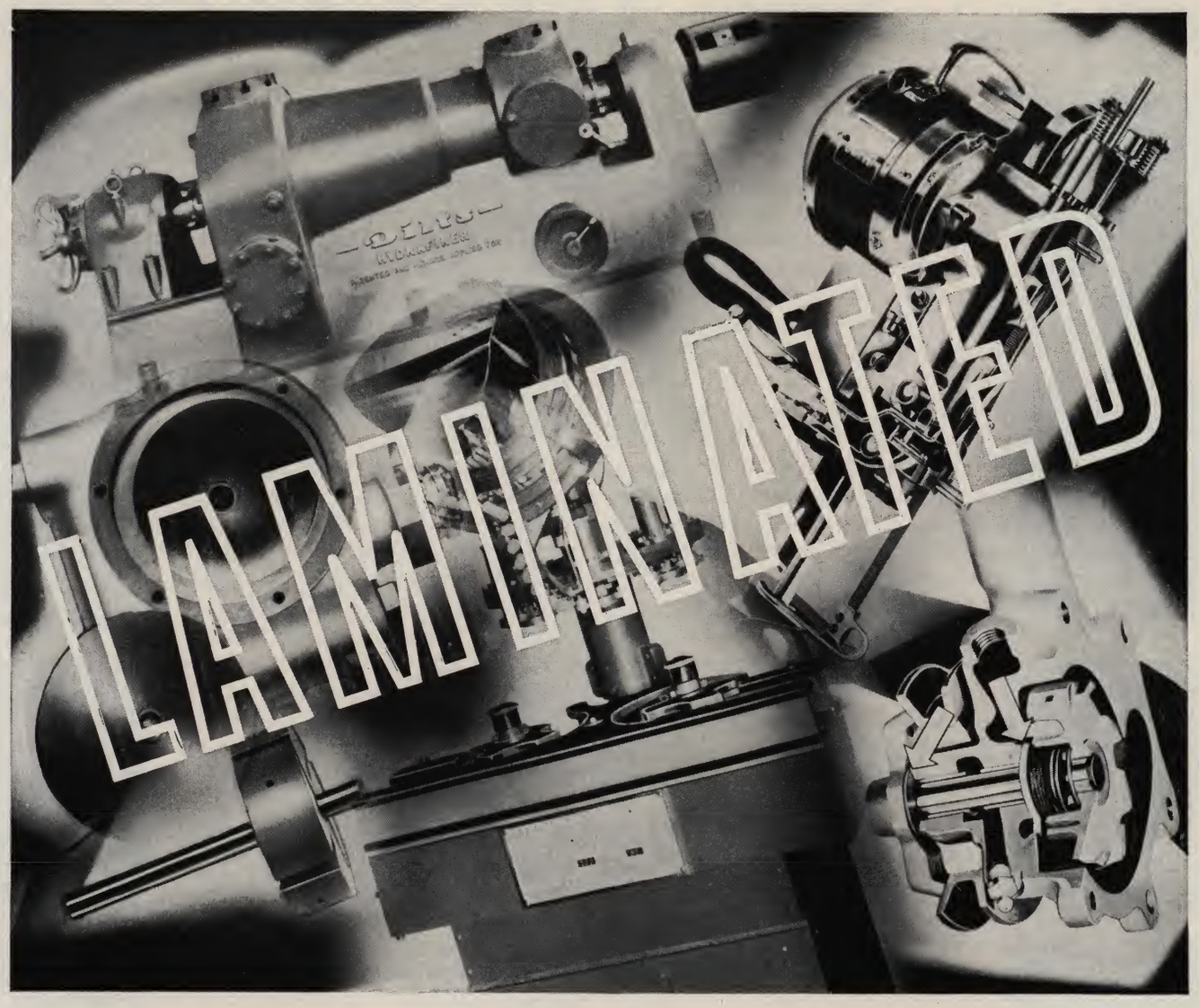
The complete success of gears made from this material depends upon the following facts: High resiliency, 40 times as resilient as steel, resulting in low impact and acceleration load stresses incidental to normal gear tooth action; stability under all operating conditions, including changes in temperature and humidity; and resistance to oils, greases, gasolines and solvents.

These same properties are desirable in materials used on several types of flexible couplings, to relieve end thrust, thereby reducing wear, and to reduce vibration and minimize the load shocks and varying motor torques. All of these tend to reduce the strains on the motor or driver, thereby decreasing maintenance cost. In the gear type flexible coupling, a molded gear with internal teeth, meshed with a metal gear, offers the advantages of light weight and resistance to damage by oil or humidity conditions. Plate material can be easily machined to fit the driving lugs of the flexible insert-type coupling, giving the above advantages and also affording electrical insulation between the shafts. Molded rods may be used as the drive pins on the flexible pin type couplings and may be so designed that the pins are actually shear pins, shearing should an overload occur that might damage the driver or other equipment. Phenolic laminated materials will not score or adhere to metals. Therefore the metal parts of the couplings will not be damaged by the sheared pins.

Molded friction head cones for screw machine spindles and tapping machine heads, caster wheels for hand trucks and rolls for escalators are other examples illustrating the toughness and wear resistance of laminates.

The relatively high heat resistance, 150 deg. C., and stability of paper and cotton fabric materials at elevated temperatures, plus ease of machining, has opened a new, purely mechanical application. In casting inserts into iron or steel, it is necessary that the inserts be held rigidly and accurately in position, during the core baking and casting cycles. Plate material or tubing is machined to support and locate the inserts properly, while the core is formed and baked. The laminated material is then an integral part of the core as it is placed in the mold. This procedure eliminates the possibility of inserts shifting or being displaced, insuring a perfectly molded part, reducing the expense and necessity of recasting.

Some grades of phenolic laminated materials will stand the corrosive actions of dilute acids and alkalies, certain organic solvents, moisture, steam and salt water. Therefore it is an ideal material for oil pump gears, gaso-



INSUROK

Various forms, grades, sizes and thicknesses of Laminated INSUROK are available for those who wish to fabricate this superior plastic in their own shops. No special tools are required.

Others who prefer to have parts or products delivered complete, ready for assembly, will find Richardson plants fully equipped to meet their requirements.

To select Richardson as your source of supply is to make Richardson facilities and man-power an integral part of your own production processes. Literature will gladly be sent on request.

The RICHARDSON COMPANY

Melrose Park, (Chicago) Ill. Founded 1858 Lockland, (Cincinnati) Ohio
New Brunswick, N. J. Indianapolis, Ind.
Detroit Office: 4-252 G. M. Building, Phone Madison 9386
New York Office: 75 West Street, Phone Whitehall 4-4487

line pump vanes and thrust washers. Valve disks, pump and shut off valves, made from fabric base materials, are superior to those made from rubber or metal in many applications. They will not pit or warp, insuring proper seating at all times and because of the resiliency and uniform structure, will not score the valve seats. Disks made from asbestos fabric can be used in hot water or steam lines, operating as high as 400 deg. Fahrenheit.

As suction box covers on paper machines, it outlasts wood several times because of its moisture and abrasion resistance. On outboard motors, thrust washers, gaskets for the exhaust seal, co-pilot lining and co-pilot bands, fabricated from plate and tubing it resists the action of salt water and insures water-tight seals. Plating barrels, fabricated from fabric plate, give excellent service when used in cold plating solutions, as does tubing with molded fittings for pipes handling chemicals.

The acid resisting and high ratio of strength to weight properties were recognized in the rayon industry and laminated was adopted as the material for molding spinning buckets. These buckets are approximately 8 in. in diameter and spin on a vertical shaft at 8000 rpm, as the wet rayon yarn is fed into the top and caked around the inner wall. A load of yarn weighs approximately 3 lbs. so that the bucket must have sufficient strength to withstand the stress caused by the centrifugal force created by the mass of rayon and the bucket itself.

Test tube racks are easily fabricated from plate laminated and will not absorb spilled liquids, are easily cleaned, have a pleasing appearance and will stand rough handling. This is only one of the examples of the small, indispensable articles used every day by scientists and chemists that can be improved by the use of phenolic material. This same material has proven successful for making the electrolytic heads, replacing metals, of an electrolyzing unit because of its corrosion resistance. The complete assembly, including the handle, two screws and head, is fabricated from rods and tubing.

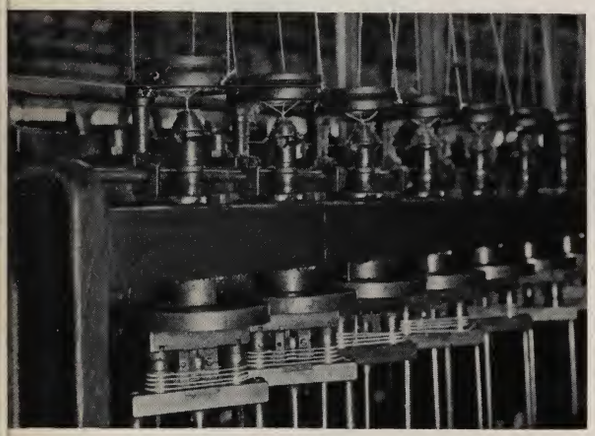
To increase the life of ball bearings at high speed, a non-abrasive, light, strong and easily machined material was needed for the ball retainer rings. Laminated fabric tubing was tried. Because of the low coefficient of friction and light weight, they require very little lubrication, yet the efficiency and life of the bearings so constructed has been materially increased.

To protect soft copper wire from abrasion as it passes through the drawing and cabling machine, laminated guides and rolls are used. Asbestos fabric base material is also used as tracks and sprockets for supporting and driving the conveyor chains in ovens at high temperatures, for treating cloth for electrical insulation purposes. The material, being non-abrasive, does not wear the conveyor and eliminates the possibility of deposited metal particles on the treated cloth. Doctor blades for paper machine rolls will not cut or score the rolls during operation. For removing light rust and refinishing the rolls after brief shut-downs, a special material containing an abrasive substance has been successfully used.

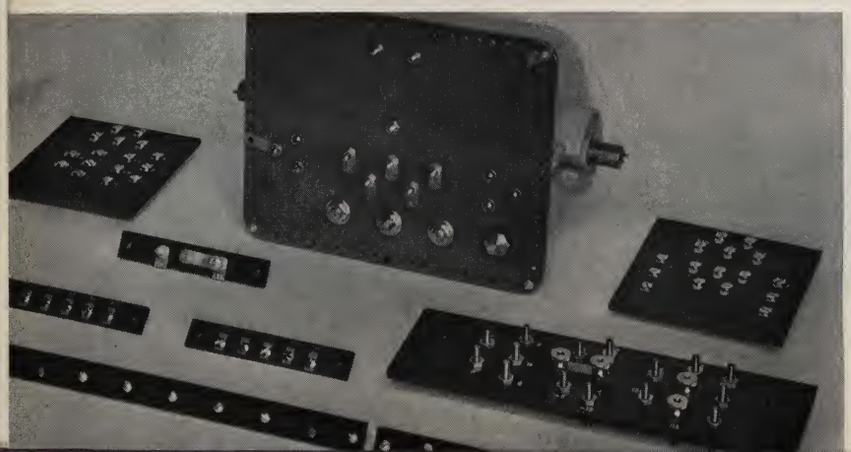
Pickers, used on looms for weaving cloth, must be tough, have a low coefficient of friction and not be affected by changes in humidity and temperature. Molded laminated pickers will fill all these requirements with added advantages that cannot be obtained with other materials. By molding to shape it is not necessary to use rivets or metal fastenings in the head, which might damage the shuttle tip or chip the openings in the box. Inserts of a soft material, molded into the stick hole, give added protection to the picker stick. An added advantage is longer life, since molded pickers outlast the conventional picker several times, if they are properly adjusted.

Bearings made from laminated fabric base materials for heavy duty applications were tried several years ago

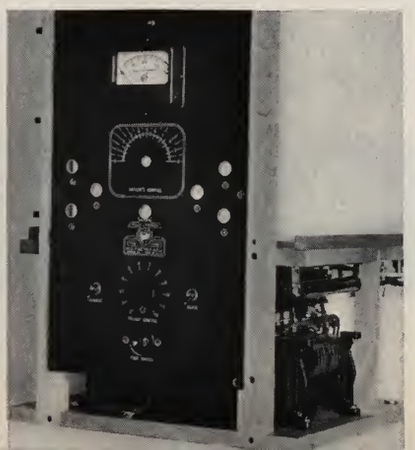
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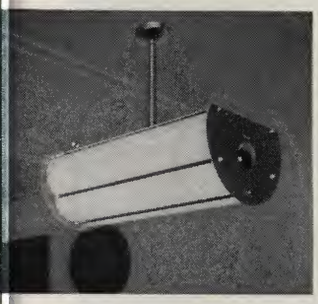


7



5—Laminated plastic Brownell flyer bushings of Micarta give long service under strenuous conditions. 6—Providing essential insulation for short wave diathermy, Dilecto laminated tube heads, lead shield, terminal strips are used for internal parts of the machine. 7—The front panel of the machine is laminated also. (Photos, courtesy Continental-Diamond Fibre Co.)

LAMICOID promotes Design and Saleability

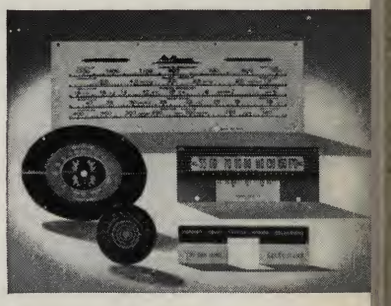


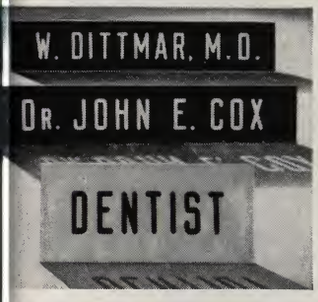
TRANSLUCENT LAMICOID

A flexible, translucent sheet of uniform structure and color, admirably suited for applications requiring rear illumination.

Non-inflammable—non-shatterable—light in weight—unaffected by moisture—easily printed and sandblasted. 10 brilliant colors and white. Glossy or satin finish. Sheets 36″ x 42″—thicknesses from .012 up.

For luminous instrument dials, signs, displays, exhibits, lighting fixtures, etc.



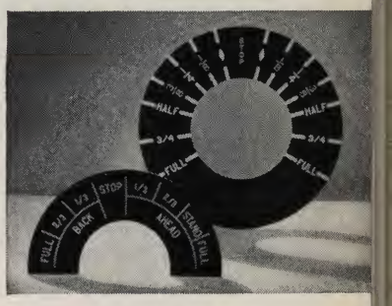


ENGRAVING LAMICOID

A "sandwich-type" sheet in which letters, figures and designs are engraved through the opaque surface exposing the contrasting core. Clean-cut and permanent—nothing to wear off. Easily drilled and machined — mechanically strong.

Available in two types:—1. OPAQUE—black surface — white core or white surface — black core. Also special color surfaces. 2. TRANSLUCENT—black opaque surface with translucent back, in brilliant colors for rear illumination.

For eye-catching display signs, nameplates, apparatus panels, announcement boards, etc.



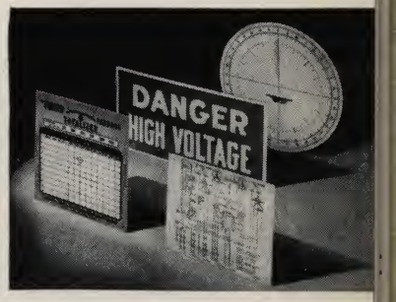


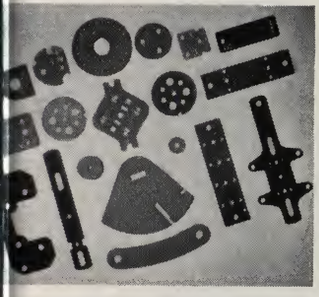
GRAPHIC LAMICOID

A durable sheet material in which printing, lettering, designs, signs, diagrams; in black and color, are permanently incorporated and cannot fade, be removed or erased. Made in two types: Opaque; and Translucent for indirect or rear illumination. Standard thickness—1/32″ and 1/16″.

Finishes—Glossy, Satin or Graphic* (a special finish suitable for writing on with pencil or ink, and erasing repeatedly without wear on the material.)

For permanent charts, wiring diagrams, maps, nameplates, dials, signs, etc.



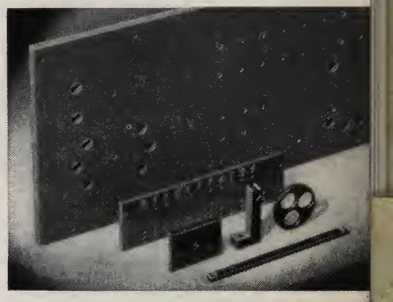


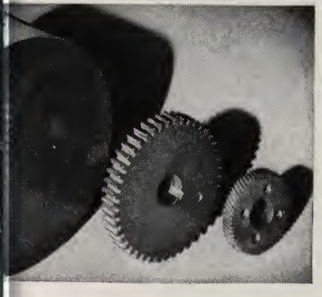
ELECTRICAL LAMICOID

Furnished in sheets, rods and tubes or as fabricated parts. They combine high dielectric strength with the extreme accuracy of machineability necessary for electrical and radio work. Easily cut and fabricated.

Low moisture absorption and low power factor plus smooth, clean-cut edges characterize punched parts—used for a wide variety of applications. Sheets in all thicknesses; standard size, 36″ x 42″. Tubes and Rods in all sizes.

For coil forms, panel boards, instrument bases, bushings, terminals, and other insulation.



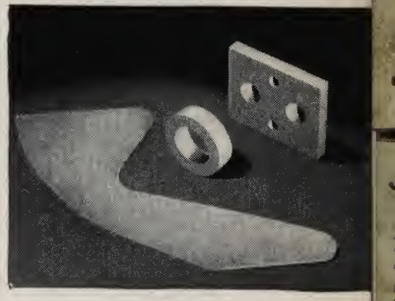


INDUSTRIAL LAMICOID

Gears and other mechanical parts made from Lamicoid fabric base Sheets, Rods or Tubes are used for a wide variety of applications. Uniformly dense, strong, resilient, and resistant to moisture and heat.

For a great many parts and accessories, these combined properties *plus* excellent machining qualities assure economical operation and longer life than can be obtained with other materials. Sheets in all thicknesses; standard size 36″ x 36″ and 36″ x 42″. Tubes and Rods in all sizes.

For all types of gears, pinions, cams, reels, gaskets, threaded bushings, etc.



LAMICOID is the registered tradename of laminated Bakelite sheets, rods and tubes made by Mica Insulator Company. They are available for a wide variety of electrical, mechanical and decorative applications in addition to those shown, and are the finest that modern machinery and research can produce.

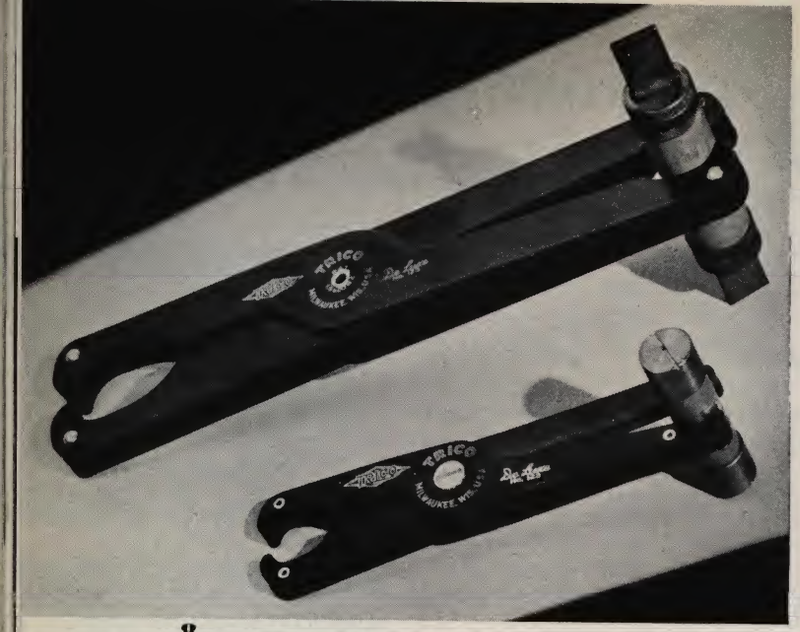
Various grades of fabric and paper base materials can be combined with special resins to meet unusual specifications such as:—resistance to oil, shock, high voltages, etc.

WRITE FOR DETAILS—We will gladly send prices and samples of any of the materials shown. When you see them, we are confident you will appreciate their great possibilities for product design and improvement. Write briefly, stating the application you have in mind.

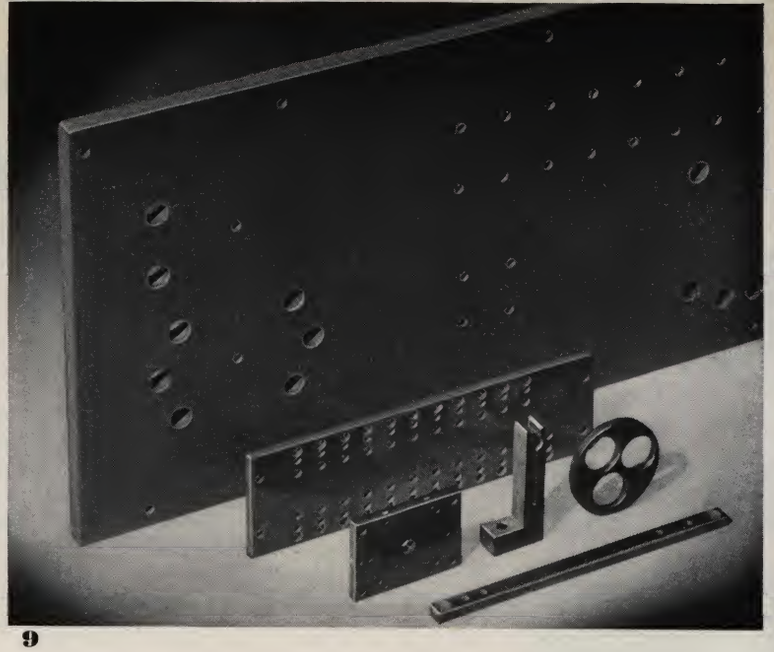
MICA INSULATOR COMPANY

200 Varick Street, New York; 542 South Dearborn Street, Chicago; 1276 West 3rd Street, Cleveland

Representatives: Cincinnati, O., Wellesley, Mass., Detroit, Mich., Birmingham, Ala., San Francisco, Cal., Los Angeles, Cal., Seattle, Wash., Houston, Texas



8



9

8—Laminated phenolic sheet stock punched and riveted together by National Vulcanized Fibre Co. provides perfect insulation for the Trico fuse puller. 9—Accurately machined Lamicoid canvas and paper-base parts for short-wave radio work have low moisture absorption and low power factor. They are easily cut on a standard drilling or threading machine, dimensions are stable, and parts will not chip or fracture (Photos, courtesy Mica Insulator Co.)

and proved successful almost from the start. Since then, many installations have been made in rolling mills for rolling sheet and nonferrous metals. They are used on plate mills, bar and billet mills, rod mills, strip mills, skelp mills, tube mills, pipe welding rolls, three high sheet mills, cold sheet mills, structural mills, as well as on auxiliary apparatus. About the only mills where laminated phenolic bearings are not practical are the two high hot sheet mills, where the rolls are operated at temperatures of 500 to 800 deg. F. and the necks cannot be water cooled.

Since the heat conductivity of phenolic laminated material is very low, approximately 2 BTU per sq. ft. per in. of thickness, per hour, per deg. F., it is necessary to provide some external means for reducing the heat of friction at the bearings. This is done by spraying water on the roll necks and at the same time the water acts as a lubricant. If properly and adequately supplied with water, laminated bearings are stable, long wearing and efficient. If the water supply should fail, the bearings will overheat and char on the surface, materially reducing the bearing life.

The economies effected by the use of laminated bearings are responsible for their increased use in the rolling mill industry. Of major importance is the saving in power, brought about by the low coefficient of friction, with water lubrication. Savings in power range from 15 to 40 percent and in some cases have been reported as high as 60 percent. When properly installed and lubricated, these bearings will outlast bronze or babbitt bearings from 5 to 10 times.

Why are phenolic laminated bearings successful? From a series of laboratory tests it has been found that at high bearing pressures the coefficient of friction is extremely low, indicating that there is film lubrication. As previously stated, the modulus of elasticity of phenolic laminated bearings is very low, considerably lower than for bearing metals. Considering the usual theory for oil film lubrication on rigid bodies, the pressure tends to concentrate at the point of minimum thickness of the film and such pressure is sufficiently high to cause an appreciable compression of the laminated bearing, distorting it in such a way that the oil film does not decrease in thickness as much as it would with the rigid bearing under the same total loading. This results in a more even distribution of pressure over the entire lubricating film and less pressure concentration.

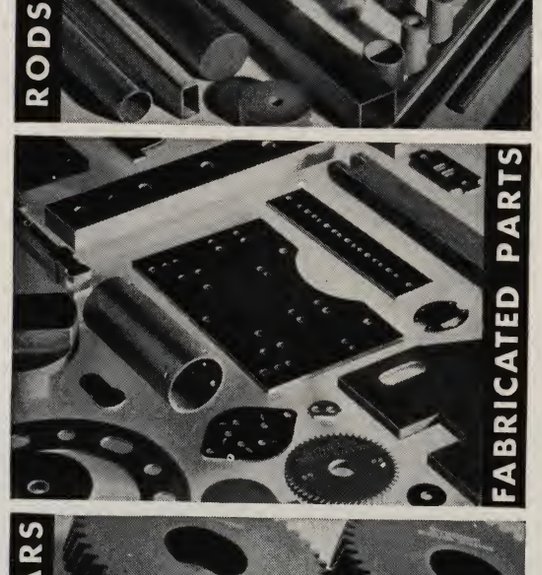
Another advantage of phenolic laminated bearings is the lack of scoring of the journals, should the lubrication system fail. Even though the surface of the bearing became badly charred, it would not score the polished journal surface, nor will laminated bearings cold flow or squeeze out as do babbitt and bronze under heavy and intermittent impact loads.

Other applications for phenolic bearings are in the manufacture of paper, where the wet process makes water lubricated bearings possible and in some cases desirable, or on any application where the heat of friction can be reduced by the use of water or other means; on grease lubricated bearings that are used intermittently and the heat of friction is carried off through the shaft; also on bearings subjected to heavy impact loads in intermittent service and on similar applications where grease or oil must be used sparingly to keep from contaminating the finished product.

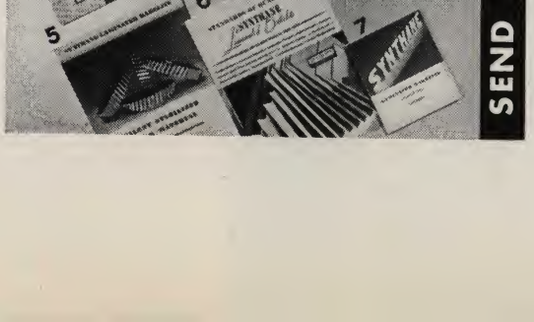
Trade names

Aqualite, Duraloy, Formica, Insurok, Lamicoid, Micarta, Phenolite, Spauldite, Synthane, Taylor, Textolite.









SYNTHANE

• Bakelite—laminated •

SYNTHANE consists of layers or laminations of bakelite–impregnated paper or fabric, transformed under heat and pressure into a dense, homogeneous solid. It is an unusual material, one of the best of electrical insulators, strong structurally, chemically inert, infusible and insoluble.

PROPERTIES

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MECHANICAL: High tensile, compressive and flexural strength. May be easily sawed, turned, punched, riveted, milled, threaded, drilled, tapped or polished.

ELECTRICAL: High dielectric strength, low dielectric constant, low power factor, low loss factor.

CHEMICAL: Resists many acids, salts, solvents, oils, and gases. Will not corrode metal inserts, bushings, ferrules, etc.

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KINDS OF STOCK: SYNTHANE is available in three principal grades, depending on the materials used in their manufacture:

1. The paper base grades: X, XX, XXX, XP, XXP, XXXP
2. The fabric base grades: C, CE, L, LE
3. The asbestos base grades: A and AA

COLORS: Natural or black. Others on request.

FINISHES: Dull or high gloss.

SIZES: Standard Sheets 36" x 36", thicknesses .010" upwards. Tubes, inside and outside diameters to order, lengths 18" and 36". Longer lengths in rolled tubing to order.

HOW TO CHOOSE THE RIGHT MATERIAL

As the choice of the proper grade of SYNTHANE frequently depends on a combination of desirable characteristics rather than one, we recommend you put your problem up to engineers at the plant, Oaks, Penna., or one of SYNTHANE'S representatives.

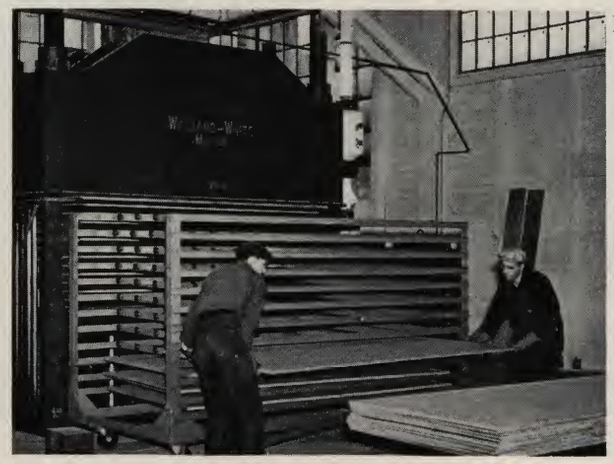
SUGGESTION—Interesting folders are available on 1. SYNTHANE Bakelite-laminated Technical Plastics for Industry, 2. Practical Methods of Machining SYNTHANE, 3. SYNTHANE Radio Insulation, 4. SYNTHANE Tubing, 5. SYNTHANE Silent Stabilized Gear Material, 6. Standards of Quality for Bakelite-laminated sheets, 7. SYNTHANE Sample Book (Actual samples).

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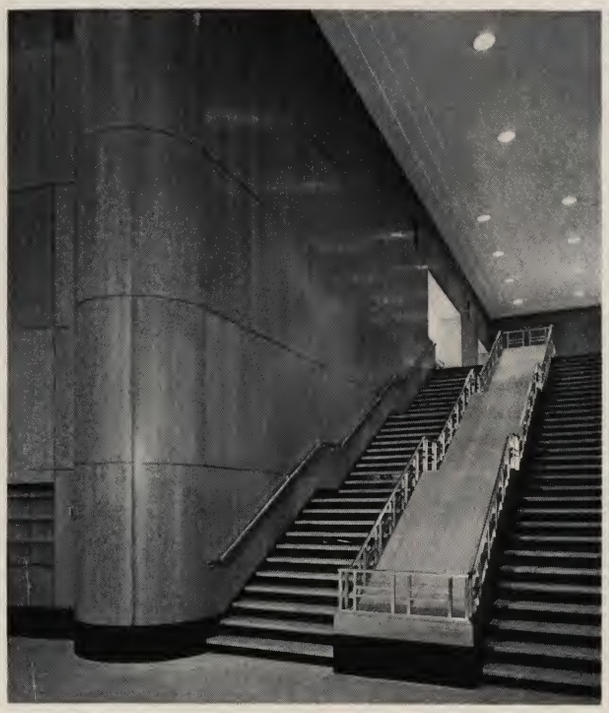
Resin bonded plywood



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IT IS far from exaggeration to describe the use of synthetic resins as plywood adhesives as a method of streamlining plywood manufacture. It has reduced the "gluing" time from days to minutes, and has at the same time made possible standards of quality and uniformity hitherto unknown to the industry.

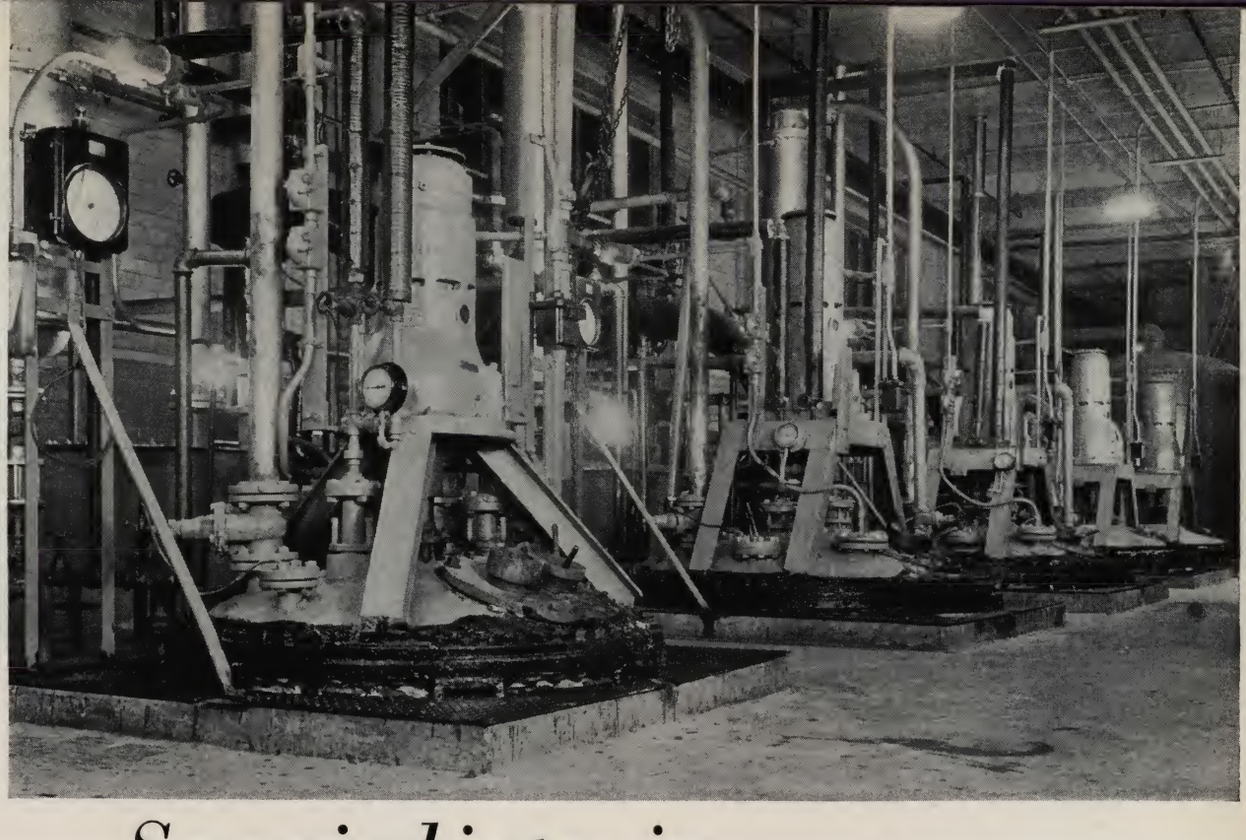
Types of resin used

At the present time, two types of resins are widely used in the hot press bonding of plywood—phenol-formaldehyde resins in sheet form and phenol-formaldehyde resins and urea-formaldehyde resins in liquid form. In the use of the first type, the dimensioned veneers or *plies* are laid up in alternate layers—wood, resin film, wood, resin film, wood, etc. In the case of liquid resins, the alternate veneers are spread on two sides by means of mechanical spreaders and then laid up in similar fashion. Thereafter, the processes are identical. The laid-up veneers are placed between aluminum cauls and inserted in multiplaten hot presses, where the resin is cured under heat and pressure (240 deg. to 320 deg. F. and 150 –300 lbs. per sq. in.) for an interval from three to thirty minutes, depending on the thickness of the assembly. The plywood, permanently fused together, is then removed from the press and cooled, after which it is ready for use.

The production advantages of a process of this type, as compared with older methods, are obvious. On one standard type of press in general use, the output can be maintained at over 1500 sq. ft. of plywood an hour for a five-ply panel. Depending on the nature of the assembly, the press capacity and other factors, the output may be even greater. In any case, the heat-curing resins have reduced the *gluing* time and operation to such a minimum that older adhesives can scarcely outweigh this advantage, even with lower initial price.

The rapidity with which the plywood industry has adopted resin bonding as standard for quality output is demonstrated by the number of hot presses which have been installed in the last five years. At the end of 1935—the first year in which suitable resins were avail-

1—Multiple platen hydraulic hot press for compressing and setting resin-bonded plywood. (Photo, courtesy Williams, White & Co.) 2—Inspecting sheet of Tego resin film (phenol-formaldehyde) used as bonding agent in manufacturing durable exterior plywood. 3—Githeus-Keally, architects, have used resin-bonded wood panels as structural, decorative material in the new Brooklyn Central Library. Bonding material by Resinous Products & Chemical Co. (Photo, courtesy American Plywood Corp.)



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FOR over 15 years The Resinous Products and Chemical Company has specialized in synthetic resins and related products. This specialization, supported by a continuous program of research, has enabled us to anticipate the needs of industry by introducing today the resins of tomorrow. We have had the privilege of pioneering the development of synthetic resins for the following industries:





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AMBEROL—phenol formaldehyde type.
PARAPLEX and DURAPLEX—alkyd type.
AQUAPLEX—alkyd resin emulsion.
UFORMITE—urea formaldehyde type.
ACRYLOID—acrylic ester type.
OILSOLATE—synthetic organic driers.

For the Plywood Industry

TEGO RESIN FILM—phenol formaldehyde sheets.
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AMBEROL PARAPLEX UFORMITE DURAPLEX AQUAPLEX ACRYLOID



4—The "Summit" plastic-plywood plane made by the Vidal process in cooperation with U. S. Plywood Corp. is used as an airplane trainer 4

able in this country—13 hot presses had been installed. Since that time, the total has reached well over 100.

Practical commercial bonding of plywood with synthetic resins began with the introduction in this country of a phenol-formaldehyde resin in sheet form, first manufactured in this country in 1935 after several years of successful service abroad. The dry film process still remains the standard of quality plywood. It makes possible completely weather- and water-proof plywood and combines to a maximum degree the most desirable features from an operating standpoint—uniformity of spread, cleanliness and precision of operation, absence of glue water, freedom from surface penetration and stain, and numerous other advantages. In addition it offers a length and diversity of service which have made it the hallmark of highest quality plywood.

Subsequent to the introduction of resin film, it was realized that there was a definite place for a resinous adhesive which would combine the production advantages of the resin film with the economies demanded by types of work where the extreme weather and water resistance was not required. This demand was met by the introduction of the urea-formaldehyde resins, which are now available in both liquid and solid form. These resins give bonds which, while somewhat below resin film bonds in quality, are far superior to animal and vegetable glues. At the same time, they may be extended or diluted with inert material, such as rye or wheat flour, to give a glue line cost sufficiently flexible to meet the requirements of all types of plywood. In addition, this type of resin cures at lower temperatures and in shorter time than the film type resin.

Resins which cure at room temperatures also have a place in the resin bonding picture, particularly in constructions where hot pressing is impractical, such as curved and serpentine furniture fronts, self-retentive joints and compound lumber blocks. One manufacturer reports the development of a phenolic resin which cures at a low temperature, thereby minimizing the tendency to check. Considerations of quality, economy and uniformity, however, emphasize the desirability of hot pressing wherever this is practical.

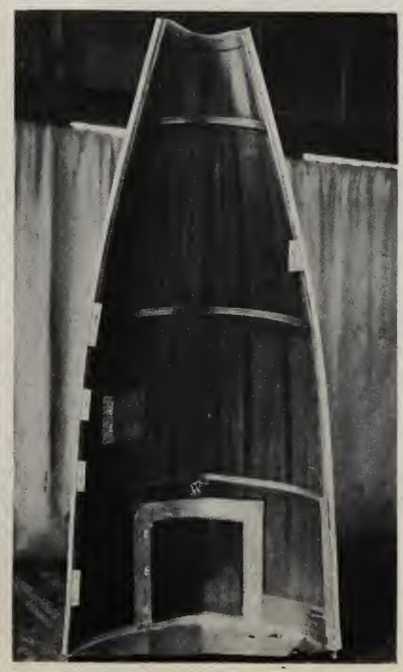
Broader markets

Commercial developments in resin-bonded plywood include, foremost, the extension into much broader mar-

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5—Smooth contours, stable dimensions and long service life are achieved by plastic-plywood construction in the fuselage of this Fairchild plane. 6—Interior view of experimental nacelle for transport plane formed by the Duramold method using resins for adhesives

kets. The flexibility of cost obtainable with the urea-formaldehyde resins and their high relative durability have permitted their introduction into various grades of stock panels and mass-produced, inexpensive furniture.

For several years the best grades of furniture have been made with resin-film-bonded panels or two-ply veneer faces, to offer the best possible protection against separation and surface checking. Some of the manufacturers ultimately installed hot presses themselves and have, since then, had an increasing business in film-bonded, completely exposure-proof furniture.

However, this has accounted for only a small fraction of the furniture made in this country and only in the past year or two did such large producing areas as the South and Northwest go into resin bonding on a large scale, on the basis of the extensible urea-formaldehyde resins. While film-bonded face veneers are ever more widely employed to give maximum quality on the exposed surface, the liquid resin has succeeded in displacing less durable adhesives even in the cheapest of the other parts. This has probably been the greatest forward step in the technical standards and prestige of the furniture industry in decades. Dealers, who have been little interested in the technical side of furniture, appreciate what resin bonding means to them.

Of like significance is the spread of resin bonding into lower-cost automotive forms and stock panels. In the Northwest, the large Douglas fir industry already has a growing number of hot presses in operation for bonding with various types of liquid resins. This has been a vital factor in the recent elevation of trade standards in the fir industry, which are now supported by rigid association specifications. All Douglas fir plywood is produced by panel plants for outside sale.

In a similar field, cheaper Eastern hardwoods, such as gum, are now resin-bonded into durable, low-cost stock panels, which have some very decided advantages over coniferous plywood. Lately, even pine is being utilized in ply construction, fabricated in hot presses with liquid resin. These products mean much to the wood industry in its sales to the building trade, which, until the advent of resins, often sacrificed the unique advantages of wood panels principally because of their uncertain integrity.

The past year has also seen a wider spread of resin-bonded plywood in industries that had already made earlier use of it. These include the radio, air-conditioning, aircraft and automotive industries, among many others. The products of Philco, RCA, Zenith, Chrysler, G-E, Packard, Bellanca—all embody resin-bonded plywood in their construction, to give prolonged service at economical cost. Incidentally, from the standpoint of synthetic resin, there is only a difference in degree be-

7



7—Complete house, inside and out, is constructed of weather-proof Resnprest Durez bonded plywood. Note the smooth rounded surfaces. 8—Huge concrete piers for Puget Sound Narrows Bridge were all poured and set in Resnprest plywood forms. 9—Section of the plywood forms still intact and usable after being used, and re-used, submerged 93 days in salt water and dried

PHOTOS, COURTESY M & M WOODWORKING CO.

8



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10—Fybr-Tech plywood combination luggage rack and air conditioning conduit for Greyhound buses is made of fibrous material bonded with Tego resin glue. 11—The construction consists of hot pressing two sheets of fiber .015 in. interlayed with adhesive agent. Subsequent forming is done as specifications necessitate. (Material, National Vulcanized Fibre Co. and American Plywood Corp.)

tween a small radio built of resin-laminated wood and a similar one molded of resin and filler (with simulated wood grain).

Most recently, particular attention has been focused on plywood in the light of the national defense program. Aeronautical engineers have long appreciated the virtues of plywood, but have turned to metals because, among other things, the strength factors of metal had been more thoroughly investigated. The present national emergency has again emphasized the possibility afforded by resin-bonded plywood as a means of speeding up production. In Europe, millions of square feet of resin-bonded plywood are being used in the production of military aircraft. It offers, among other advantages, the possibility of utilizing carpenters and other woodworkers in plane construction, rather than metal workers requiring many years of training in their trade. Still another development is the so-called plastic-plywood plane, made by the Vidal and Duramold processes, which is nothing more nor less than the intelligent application of plywood technique to aircraft production.

An interesting sidelight is the use of resin film in the manufacture of plywood beer barrel staves, now a commercial reality. Laminated beer barrels not only reduce the demand for seasoned oak, now relatively scarce, but provide an improved barrel of longer service life.

The greatest probable use for resin-bonded plywood is for building construction, and it has found its place in the exteriors of houses, gasoline stations, farm buildings, store fronts, portable buildings of various types, trailers, garage type doors, water tanks, roofing, door fronts. It is playing an important part in the interior construction of refrigeration plants for walls, partitions, doors, etc.

Phenolic resin plywood, giving a water-proof bond and being practical for use in lighter sections or thicknesses than standard lumber, is used extensively in boat building. In concrete forms it is found economical because the large sections are easy to handle and it is practical for fairly long re-use. Resin-bonded plywood was used for gusset plates on the San Francisco bridge and for concrete forms on the Puget Sound Bridge near Tacoma, Washington. The forms were used fifteen times, submerged ninety-three days in salt water and remained intact and were still usable.

A special product based on the combination of synthetic resin and wood is the multi-ply type of aggregate bonded under higher pressures, sometimes known as *improved wood*. The resin can be introduced in the form of liquid or film. The former gives a harder, stiffer product throughout the mass and has certain difficulties of uniform application. The film gives an extremely durable joint between the thin veneers, without impregnating the wood appreciably, which leaves the latter in a tough resilient condition. Both types have seen service for some time in Europe, where raw material conditions favor them, but their specific properties also indicate a wider use in this country.

A certain hardness, toughness and shock resistance characterize this class of product, as compared with other materials. To some extent it serves as replacement and improvement, as in gear wheels, aircraft struts and propellers, gun stocks, casters and the like. Its cost is relatively high but it is readily machined and usually gives long service. The German Schwartz propeller, which has been rather fully described, is built up of compressed, resin-bonded veneers and its service record over a period of years has been superb. There have been developments along similar lines in the American and British aircraft industries. In the same industry, *improved wood* is also serving in forms for molding light metal sheets, in place of steel dies.

Improved wood is also a promising substitute for certain species of solid wood, which are becoming scarce and expensive or have for other reasons proved inadequate. Such species as dogwood, persimmon, hickory and maple can readily be surpassed in their best properties by suitable veneer constructions of common woods, offering a uniformity and freedom of design not otherwise possible.

Resin bonding of plywood has brought engineering standards to an industry that long suffered from numerous uncontrollable and immeasurable variables (e.g., moisture distribution, grain direction, etc.). In resin-bonded wood, the combination of resin and wood has been brought to a technical point where a desired combination of physical properties can be predicted and designed in advance. This represents an excellent practical utilization of both resin and solid wood fiber, with their many desirable and complementary properties.

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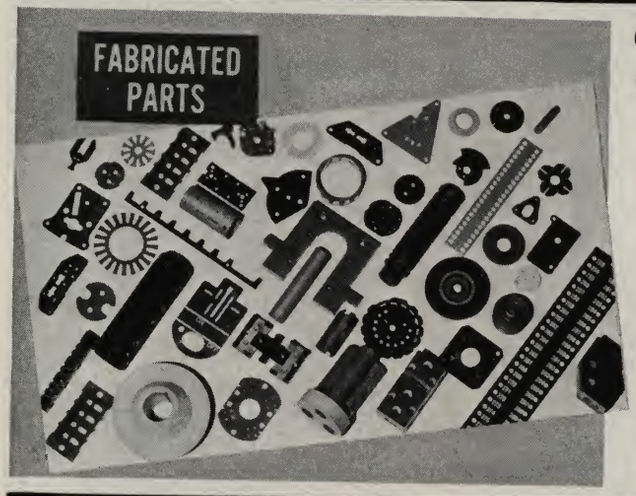
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PLASTIC COATINGS

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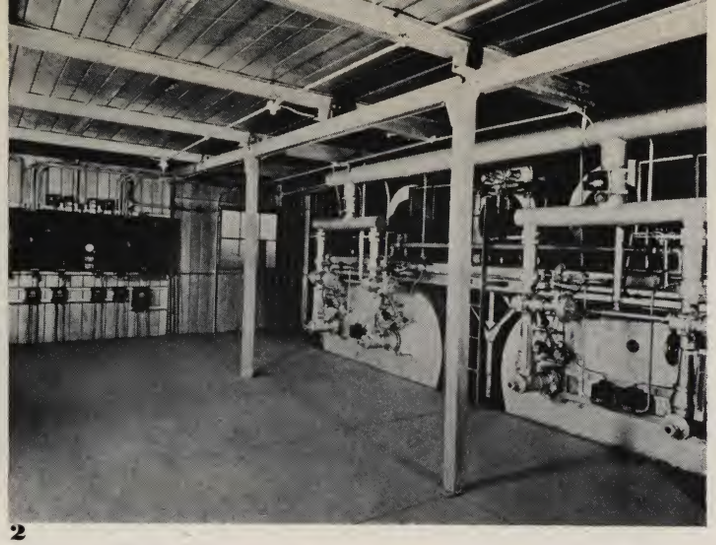
Solvents chart—Opposite 424

Plasticizers chart—Opposite 446





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1—Convection type oven installed by R. C. Mahon Co. at a Remington Rand plant for baking resin-base enameled metal parts. Baking enamels based on urea and melamine resins are finding rapidly expanding use for finishing a wide variety of household appliances. 2—Heating equipment and control panels at Maytag plant. Equipment is designed to meet fluctuating production conditions. (All photos, courtesy American Cyanamid & Chemical Corp.)

Amino resins for coatings*

IN the intensive development of a wide variety of synthetic resins which has occurred during the past quarter century, a number of amino compounds have been included among the raw materials investigated. From them two groups of resins based on amino materials have emerged to positions of real commercial utility and importance in the surface coating industry. These are made, respectively, from urea and melamine, the first familiar through use over a period of many years, the latter of more recent commercial interest. They are both thermosetting types with some points of general similarity. They differ, however, in specific and important characteristics and should therefore be studied as separate groups.

Urea resins

Under properly controlled conditions urea reacts readily with formaldehyde to form products of resinous characteristics which may be dispersed in organic media. The term "urea" is now commonly used by the paint trade in a generic sense to designate not only resins in which such urea-formaldehyde compounds predominate but also those which are modified by the inclusion of alkyd resins and other materials. The demand for such resins from the paint and varnish industry has developed so rapidly in the past few years as to now fully equal in importance their formerly more familiar uses in molding, laminating, textile treatment and adhesives.

Urea resins suitable for use in surface coatings are supplied to the trade as concentrated solutions in alcohols or in mixtures of alcohols and hydrocarbons. Mixtures of butanol and xylol are most frequently used although octyl, capryl and other alcohols as well as toluol, mineral spirits and other hydrocarbons are used to secure special characteristics. From a practical standpoint the urea resins supplied to the paint industry can be divided into two groups:

(1) The so-called *straight* types which are solutions of urea-formaldehyde resins alone. These are practically colorless and yield films which are very hard but relatively brittle.

(2) The "*modified*" resins which are predominately urea types in composition and characteristics but which are modified by inclusion of alkyd resins or other materials to alter distensibility, adhesion and other characteristics. The extent to which such resins retain the pale color, resistance to discoloration, hardness and baking speed of *straight* urea types depends of course on the kind and proportion of modifying material.

Coatings made from these resin solutions are generally thinned to proper consistency with additional solvent and applied by spraying, dipping, brushing, roll or knife coating. In special instances they are emulsified with water and applied in that form.

Uses of urea resins for coatings

Urea resins have followed the general rule that as each new type of synthetic resin became available it has found

* This article was especially prepared for this issue by John McE. Sanderson, American Cyanamid & Chemical Corporation.

commercial utility in particular applications which, because of its special characteristics, it could fill to better advantage than other materials. Urea resins now used in surface coatings are thermosetting types which find their major interest in baking enamels. Such enamels when properly formulated may be baked in the range of 250 deg to 325 deg F. with much less discoloration than occurs with alkyd resins or varnish vehicles. They bake faster than previously available vehicles and have a superior degree of mar-resistant hardness even while the film is still hot, as well as having excellent resistance to grease and humidity.

The combination of color retention, baking speed and hardness imparted by the urea resins has led to their general adoption in baking enamels in white, pastel tints and dark colors. Such enamels are particularly well adapted to the finishing of refrigerators, bathroom and kitchen cabinets, hospital equipment, metal furniture, washing machines, toys, bicycles, signs, automobile bodies, stove parts, machinery and decorative metal novelties. An application of particular interest to the plastic industry is the use of urea resin baking enamels in pastel tints as a decorative finishing coat on radio cabinets and other articles molded from certain plastic resins.

With the aid of special catalysts curing temperatures can be reduced considerably. By this means the use of urea resins is being extended into special fields such as clear finishes on wood furniture where maximum baking temperatures are in the range of 105 deg. to 150 deg. F.

In addition to mixtures with alkyd resins in clear and pigmented baked coatings, these urea resins are also being used in nitrocellulose lacquers, printing inks and special coatings and as impregnants for paper, textiles and certain floor coverings.

Melamine resins

Considering the degree of inprovement imparted by urea-alkyd combinations in comparison with previously available vehicles, it might seem as though the ultimate in baking enamels had been reached. On the contrary, they have merely pointed to the opportunity for still further improvement. This is being realized through the use of resins made from melamine which have now become commercially available.

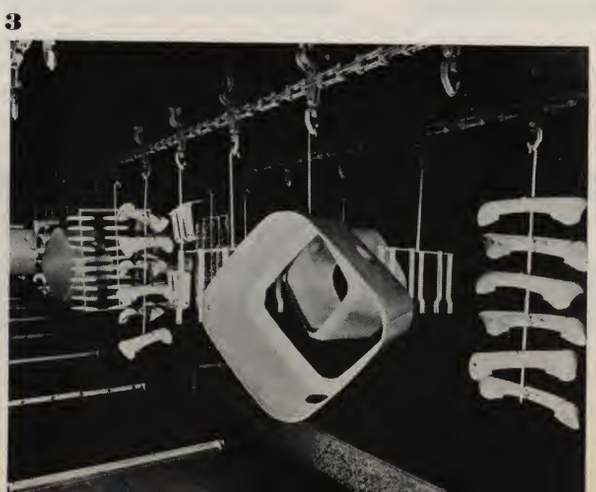
Melamine itself is a chemical compound, namely 2,4,6-triamino-1,3,5-triazine, long known in the laboratory but only recently available at a cost and in sufficient quantity to be of interest as an ingredient for synthetic resins. Combined with formaldehyde it forms resins which like those made from urea are thermosetting types which may be dispersed in organic media and used in combination with alkyd resins as vehicles for baking enamels. These coatings may be thinned with solvent or emulsified with water prior to application by spraying, dipping, brushing or roll or knife coatings.

In the use of alkyd-melamine resin enamels, one thing is immediately noted, namely, that they may be baked in a temperature range as low as 180 deg. to 225 deg. F. and still obtain the speed and hardness for which comparable enamels made from urea resins require baking temperatures of 250 deg to 325 deg. F. At the same time the enamels made from melamine show superior resistance to alkali, grease, humidity and outdoor exposure. Furthermore, these melamine resin enamels retain their gloss and color on prolonged subjection to temperatures up to 425 deg. F. while under similar conditions enamels made from urea or alkyd resins or varnish vehicles show very marked flatting and discoloration.

Uses

The wide temperature range and short times at which melamine resin enamels can be baked has led to their adoption to speed up the production line finishing of refrigerators, kitchen cabinets and other metal articles. Their resistance to high temperatures lends definite interest to their use on stove parts and electrical appliances. In their use as finishing coats over molded plastics, the low temperature at which they can be baked to mar-resistant hardness eliminates the warping and distortion which may occur at high bakes. The possibility of baking in steam-heated ovens is of interest to the metalware manufacturer who is not equipped with ovens which meet the high temperature requirements of other types of enamels. Their outdoor durability, hardness and gloss have led to the incorporation of small proportions of melamine resins in the alkyd resin baking enamels used for finishing of automobile bodies, signs and lawn furniture. They are also of interest for use in nitrocellulose lacquers, printing inks and special coatings and impregnants for paper, textiles and floor coverings.

3

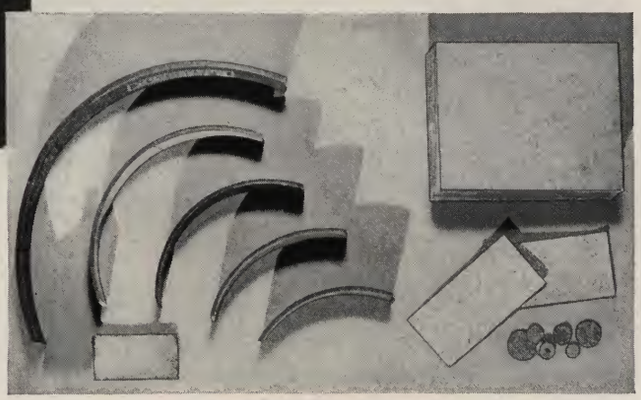


4



3—Production line of metal coated refrigerator parts passing through baking oven. 4—The surface of these kitchen cabinets are treated with urea and melamine base coatings to withstand rigorous wear

Resins that fit the job ...AND DO IT BETTER!



GENERAL BONDING

Asbestos, cork and other materials bonded with Durez resins have outstanding strength and lasting qualities. For example, brake linings bonded with these resins wear longer, give surer action.

OF ALL THE useful materials evolved by synthetic chemistry within the last decade or two, few have done more to help industry turn out better products and improve production methods than Durez phenolic resins.

Already industry has discovered thousands of jobs for these resins. They are used for bonding in scores of ways, for insulating, impregnating, coating, waterproofing, sizing and many other processes. They help produce plywood that is waterproof and vermin-proof. They make coatings and finishes tougher, glossier, more durable.

Durez resins are supplied in powder and liquid form. Under heat and pressure they set up infusibly with remarkable strength and resistance to oil, water, alcohol, heat, acids, caustics and friction. Several hundred Durez resins are available for a wide range of applications. We'll gladly help you choose the right one to fit *your* job. Just write—

DUREZ PLASTICS & CHEMICALS, INC.
10 Walck Road **North Tonawanda, N. Y.**



IMPREGNATING

Durez resins serve both as a bond and surface finish for sheet laminated materials. These materials are used for electrical insulation, silent gears and many other purposes.



PLYWOOD BONDING

Durez resin glues produce plywood of remarkable strength and weather resistance. The glue line of this wood is so tough that boiling in water will not cause the plies to separate.



COATING

Durez oil soluble resins produce paints and varnishes of remarkable toughness and elasticity, and excellent gloss. The present line is the largest and finest in Durez history.

DUREZ PLASTICS & CHEMICALS, INC.

PLASTICS THAT FIT THE JOB

Continuous Solvents Chart - 1941

Manu-

Solvents Chart - 1941

NAME	FORMULAS Empirical and Structural	Molecular Weight	Specific Gravity at 20°C	Refractive Index at 20°C	Vapor Pressure at 20°C	Boiling Point	Melting Point	Flash Point (Cleveland Open Cup)	Solubility in Water	Common or Trade Names	Manufacturer (See list at bottom of page for key to numbers)
ALCOHOLS					mm. Hg	°C	°C	°C	% by wt.		
Methyl alcohol	CH_4O CH_3OH	32	0.792	1.329	98.0	64.5	−98	15	∞	Methanol Wood alcohol	4, 5, 7, 19
Ethyl alcohol	C_2H_6O CH_3CH_2OH	46	0.791	1.3624@ 18°	44.0	78.3	−117	21	∞	Ethanol Alcohol	4, 5
n-Propyl alcohol	C_3H_8O $CH_3CH_2CH_2OH$	60	0.804	1.3854	14.5	97.2	−127	22	∞	Propanol	7
iso-Propyl alcohol	C_3H_8O $(CH_3)_2CHOH$	60	0.786	1.3776	35.0	82.4	−101	21	∞	*iso*-Propanol *sec*-Propyl alcohol	4, 19
n-Butyl alcohol	$C_4H_{10}O$ $CH_3CH_2CH_2CH_2OH$	74	0.810	1.3993	6.0	117.7	−89	46	7.9@20°	Butanol	4, 5, 10, 11, 19
iso-Butyl alcohol	$C_4H_{10}O$ $(CH_3)_2CHCH_2OH$	74	0.806	1.389	99@60	107.9	−108	27	8.7@18°	*iso*-Butanol *iso*-Propyl carbinol	7
sec-Butyl alcohol	$C_4H_{10}O$ $CH_3CH_2CHOHCH_3$	74	0.808	1.397	—	100	−89	24	11.1@20°	Methyl ethyl carbinol Butanol-2	10, 19
tert-Butyl alcohol	$C_4H_{10}O$ $(CH_3)_3COH$	74	0.789	1.3878	32	82.8	25	—	∞	—	8
n-Amyl alcohol	$C_5H_{12}O$ $CH_3CH_2CH_2CH_2CH_2OH$	88	0.817	1.4096@ 15°	—	138	−79	57	2.6@22°	*n*-Butyl carbinol Pentanol	10, 16
iso-Amyl alcohol	$C_5H_{12}O$ $(CH_3)_2CHCH_2CH_2OH$	88	0.812	1.4084@ 18°	—	130.5	−117.2	56	2.6@22°	*iso*-Butyl carbinol	16
active Amyl alcohol	$C_5H_{12}O$ $CH_3CH_2CH(CH_3)CH_2OH$	88	0.816	—	—	128	—	57	—	*sec*- Butyl carbinol	16, 19
sec-Amyl alcohol	$C_5H_{12}O$ $CH_3CH_2CH_2CHOHCH_3$	88	0.809	1.4053	—	119	—	49	5.1@30°	Methyl propyl carbinol	16
sec-Amyl alcohol	$C_5H_{12}O$ $CH_3CH_2CHOHCH_2CH_3$	88	0.815@ 52°	1.4077@ 25°	—	115.6	—	51	—	Diethyl carbinol	16
tert-Amyl alcohol	$C_5H_{12}O$ $CH_3CH_2CHOH(CH_3)_2$	88	0.809	1.4052	—	101.8	−12	23	11.1@20°	Dimethyl ethyl carbinol	16
n-Hexyl alcohol	$C_6H_{14}O$ $CH_3CH_2CH_2CH_2CH_2CH_2OH$	102	0.821	1.4161@ 25°	0.98	156.4	−51.6	32	0.58@20°	*n*-Hexanol	4
sec-Hexyl alcohol	$C_6H_{14}O$ $CH_3CH_2CH_2CH_2CHOHCH_3$	102	0.808	1.4126	3.62	131.8	—	54	1.55@20°	Methyl amyl alcohol	4
sec-Hexyl alcohol	$C_6H_{14}O$ $(C_2H_5)_2CHCH_2OH$	102	0.833	1.421	1.1	148.9	—	57	0.43@20°	Pseudohexyl alcohol 2-Ethylbutyl alcohol	4
sec-Heptyl alcohol	$C_7H_{16}O$ $CH_3CH_2CH_2CH_2CH_2CHOHCH_3$	116	0.819	1.4213	1.0	160.4	—	71	0.35@20°	Methyl hexanol Methyl amyl carbinol	4
sec-Octyl alcohol	$C_8H_{18}O$ $CH_3CH_2CH_2CH_2CH(C_2H_5)CH_2OH$	130	0.834	—	0.36	183.5	<−76	85	0.10@20°	2-Ethyl hexanol	4
sec-Octyl alcohol	$C_8H_{18}O$ $CH_3CH_2CH_2CH_2CH_2CH_2CHOHCH_3$	130	0.819	1.4260	—	178.5	−38.6	—	—	Methyl hexyl carbinol Solvent C-8	1, 15
sec-Undecyl alcohol	$C_{11}H_{24}O$ $CH_3(CH_2)_8CHOHCH_3$	172	0.836	—	0.08	225.4	12	113	<0.02@20°	Undecanol	4
sec-Tetradecyl alcohol	$C_{14}H_{30}O$	214	0.836	—	0.02	263.2	—	141	<0.02@20°	Tetradecanol	4
sec-Heptadecyl alcohol	$C_{17}H_{36}O$	256	0.848	—	<0.01	308.5	—	154	<0.01@20°	Heptadecanol	4
Crotonyl alcohol	C_4H_8O $CH_3CH{=}CHCH_2OH$	72	0.873	1.4240	—	117	<−30	—	14.2@20°	—	4
Cyclohexanol	$C_6H_{12}O$ $CH_2CH_2CH_2CH_2CH_2CHOH$	100	0.962	1.4656@ 23°	—	161.5	24	68	5.4@15°	Hexahydrophenol Hexalin	7
Methyl cyclohexanol	$C_7H_{14}O$ $CH_2CH_2CH_2CH_2CH(CH_3)CHOH$	114	0.933	1.4659@ 13°	—	165–166	−50	68	3@20°	Hexahydrocresol Methyl Hexalin	7
Benzyl alcohol	C_7H_8O $C_6H_5CH_2OH$	108	1.050@ 15°	1.5396	—	205.2	−15.3	—	3.8@17°	—	8
p-tert-Amyl *o*-cresol	$C_{12}H_{18}O$ $C_5H_{11}C_6H_3(CH_3)OH$	178	0.970	—	—	260–263	ca. 20	—	—	—	16
Diacetone alcohol	(See under KETONES)										
AMIDES and AMINES											
Acetamide	C_2H_5ON CH_3CONH_2	59	1.159	1.4274@ 78.3°	—	222	81	—	49	—	1, 12
n-Butyl amine	$C_4H_{11}N$ $CH_3CH_2CH_2CH_2NH_2$	73	0.740	1.401	—	78	−50.5	—	∞	—	4
Di-*n*-butyl amine	$C_8H_{19}N$ $(CH_3CH_2CH_2CH_2)_2NH$	129	0.768	—	—	159–161	—	—	∞	—	4
sec-Octyl amine	$C_8H_{19}N$ $CH_3(CH_2)_3CH(C_2H_5)CH_2NH_2$	129	0.792	—	—	167–168	—	—	—	—	4
Monobutyl diamyl amine	$C_{14}H_{31}N$ $C_4H_9N(C_5H_{11})_2$	213	0.788	—	—	229–241	—	—	—	—	16
Di-*sec*-octyl amine	$C_{16}H_{35}N$ $[CH_3(CH_2)_3CH(C_2H_5)CH_2]_2NH$	241	0.806	—	0.01	281	—	132	<0.02	—	4
Ethylene diamine	$C_2H_8N_2$ $NH_2CH_2CH_2NH_2$	60	0.899	1.4540@ 26.1°	11.0	117	8.5	43	∞	—	4
Propylene diamine	$C_3H_{10}N_2$ $NH_2CH(CH_3)CH_2NH_2$	74	0.873	—	11.7	119.7	—	71	∞	—	4
Diethylene triamine	$C_4H_{13}N_3$ $NH_2C_2H_4NHC_2H_4NH_2$	103	0.954	—	0.22	206.7	—	102	∞	—	4
Triethylene tetramine	$C_6H_{18}N_4$ $NH_2C_2H_4NHC_2H_4NHC_2H_4NH_2$	146	0.982	—	<0.01	277.5	—	127	∞	—	4
Tetraethylene pentamine	$C_8H_{23}N_5$ $NH_2(CH_2CH_2NH)_3CH_2CH_2NH_2$	189	0.999	—	<0.01	333	—	—	∞	—	4
Monoethanolamine	C_2H_7ON $HOCH_2CH_2NH_2$	61	1.018	1.4539	0.48	171	10.5	93	∞	—	4
Mono-*iso*-propanolamine	C_3H_9ON $CH_3CHOHCH_2NH_2$	75	0.981	—	—	@5 mm. 45	—	—	∞	—	4
Diethylaminoethanol	$C_6H_{15}ON$ $(C_2H_5)_2NC_2H_4OH$	117	0.885	—	2.1	162	—	60	∞	—	4
Di-*sec*-octylaminoethanol	$C_{18}H_{39}ON$ $[CH_3(CH_2)_3CH(C_2H_5)CH_2]_2NC_2H_4OH$	286	—	—	—	—	—	—	Insoluble	—	4
Diethanolamine	$C_4H_{11}O_2N$ $(HOCH_2CH_2)_2NH$	105	1.098	1.4776	<0.01	268	28	138	∞	—	4
Di-*iso*-propanolamine	$C_6H_{15}O_2N$ $(CH_3CHOHCH_2)_2NH$	133	1.009	—	—	116 @5 mm.	—	—	∞	—	4
Triethanolamine	$C_6H_{15}O_3N$ $(HOCH_2CH_2)_3N$	149	1.126	1.4852	<0.01	208 @10 mm.	21	185	∞	—	4
Tri-*iso*-propanolamine	$C_9H_{21}O_3N$ $(CH_3CHOHCH_2)_3N$	191	1.020	—	<0.1	305	—	152	∞	—	4
Hydroxyethyl ethylene diamine	$C_4H_{12}ON_2$ $NH_2CH_2CH_2NHC_2H_4OH$	104	1.030	—	0.02	244	—	135	∞	—	4
Diamyl nitrosoamine	$C_{10}H_{22}ON_2$ $(C_5H_{11})_2NNO$	186	0.891	—	—	120–130@ 10 mm.	—	—	—	—	16
Morpholine	C_4H_9ON $CH_2CH_2OCH_2CH_2NH$	87	1.002	—	11.1	129	—	38	∞	—	4
Morpholine ethanol	$C_6H_{13}O_2N$										

Morpholine	C_4H_9ON $CH_2CH_2OCH_2CH_2NH$	87	1.002	—	11.1	129	—	38	∞	—	4
Morpholine ethanol	$C_6H_{13}O_2N$ $CH_2CH_2OCH_2CH_2NC_2H_4OH$	131	1.072	—	0.11	225.5	—	99	∞	—	4
Morpholine ethanol ethyl ether	$C_8H_{17}O_2N$ $C_2H_4OC_2H_4NC_2H_4OC_2H_5$	159	0.965	—	<0.3	206	—	—	∞	—	4
Phenyl morpholine	$C_{10}H_{13}ON$ $C_6H_5NCH_2CH_2OCH_2CH_2$	163	—	—	<0.01	—	57	—	1.0	—	4
N-Mono-*n*-butyl aniline	$C_{10}H_{15}N$ $C_6H_5NHC_4H_9$	149	0.925	—	—	234–242	—	—	Slightly Soluble	—	16
N-Monoamyl aniline	$C_{11}H_{17}N$ $C_6H_5NC_5H_{11}$	163	0.916	—	—	245–260	—	—	—	—	16
N-Di-*n*-butyl aniline	$C_{14}H_{23}N$ $C_6H_5N(C_4H_9)_2$	205	0.904	—	—	267–275	—	—	Insoluble	—	16
N-Diamyl aniline	$C_{16}H_{27}N$ $C_6H_5N(C_5H_{11})_2$	233	0.898	—	—	276–292	—	—	—	—	16
N-*n*-Butyl *α*-naphthyl-amine	$C_{14}H_{17}N$ $C_{10}H_7NHC_4H_9$	199	1.012	—	—	318–325	—	—	—	—	16
Hydroxyethyl aniline	$C_8H_{11}ON$ $C_6H_5NHC_2H_4OH$	137	1.097	—	<0.1	285	—	—	4.58	Phenyl ethanol-amine	4
Hydroxyethyl ethyl aniline	$C_{10}H_{15}ON$ $C_6H_5N(C_2H_5)C_2H_4OH$	165	1.04	—	—	268@ 740 mm.	—	—	0.50	Ethyl phenyl ethan-olamine	4
Di-hydroxyethyl aniline	$C_{10}H_{15}O_2N$ $C_6H_5N(C_2H_4OH)_2$	181	—	—	<0.1	—	58	—	3.34	Phenyl diethanol-amine	4
ESTERS											
Diethyl carbonate	$C_5H_{10}O_3$ $(C_2H_5O)_2CO$	118	0.975	1.3852	—	126	−43	32	1.4	—	19
Methyl formate	$HCOOCH_3$ $C_2H_4O_2$	60	0.975	1.344	476	31.8	−100	−12	23.3	—	5, 7
Ethyl formate	$C_3H_6O_2$ $HCOOC_2H_5$	74	0.924@ 25°	1.3597	193	54.3	−80.5	−19.5	10.5	—	5
Methyl acetate	$C_3H_6O_2$ CH_3COOCH_3	74	0.935	1.3593	166	57.1	−98.1	−4	24.2	—	4, 7, 12
Ethyl acetate	$C_4H_8O_2$ $CH_3COOC_2H_5$	88	0.902	1.3725	65	77	−83.6	4	8.72	—	4, 5, 10 11, 19
iso-Propyl acetate	$C_5H_{10}O_2$ $CH_3COOCH(CH_3)_2$	102	0.874	1.3775	48.0	89	−73.4	16	2.91	—	4, 19
n-Butyl acetate	$C_6H_{12}O_2$ $CH_3COOC_4H_9$	116	0.883	1.3951	10.1	126.5	−76.8	38	0.68	—	4, 5, 10, 11, 19
iso-Butyl acetate	$C_6H_{12}O_2$ $CH_3COOCH_2CH(CH_3)_2$	116	0.868@ 25°	1.388@ 25°	—	118.3	−98.9	25	0.52	—	7
sec-Butyl acetate	$C_6H_{12}O_2$ $CH_3COOCH(CH_3)CH_2CH_3$	116	0.865	1.3915	—	112.2	—	19	0.8	—	10, 19
n-Amyl acetate	$C_7H_{14}O_2$ $CH_3COOC_5H_{11}$	130	0.879	1.4012	—	147.6	—	26	0.18	Commercial or technical grades are mixtures of isomers	5, 10, 11 16, 19
sec-Amyl acetate	$C_7H_{14}O_2$ $CH_3COOC_5H_{11}$	130	0.864	1.3960	—	123–145	—	32	—		19
sec-Hexyl acetate	$C_8H_{16}O_2$ $CH_3COOCH(CH_3)CH_2CH(CH_3)_2$	144	0.860	—	1.17	146.3	—	43	0.13	Methyl amyl acetate	4
sec-Octyl acetate	$C_{10}H_{20}O_2$ $CH_3COOCH_2CH(C_2H_5)C_4H_9$	172	0.873	—	0.40	198.6	—	88	0.13	2-Ethylhexyl acetate	4
Methyl acetoacetate	$C_5H_8O_3$ $CH_3COCH_2COOCH_3$	116	1.078	1.4184	1.35	171.7	—	77	44.5	—	4
Ethyl acetoacetate	$C_6H_{10}O_3$ $CH_3COCH_2COOC_2H_5$	130	1.026	1.4209@ 16.6	0.85	180.7	<−80	85	11.6	—	4, 19
Ethylene glycol mono-methyl ether acetate	$C_5H_{10}O_3$ $CH_3COOCH_2CH_2OCH_3$	118	1.007	—	3.73	144.5	—	60	∞	Methyl Cellosolve acetate	4
Ethylene glycol monoethyl ether acetate	$C_6H_{12}O_3$ $CH_3COOCH_2CH_2OC_2H_5$	132	0.975	—	1.09	156.3	—	60	23.0	Cellosolve acetate	4
Diethylene glycol mono-methyl ether acetate	$C_7H_{14}O_4$ $CH_3COOC_2H_4OC_2H_4OCH_3$	162	1.040	—	0.12	209.1	—	82	∞	Methyl Carbitol acetate	4
Diethylene glycol monoethyl ether acetate	$C_8H_{16}O_4$ $CH_3COOC_2H_4OC_2H_4OC_2H_5$	176	1.011	—	0.15	217.7	—	110	∞	Carbitol acetate	4
Diethylene glycol mono-butyl ether acetate	$C_{10}H_{20}O_4$ $CH_3COOC_2H_4OC_2H_4OC_4H_9$	204	0.981	—	0.04	246.4	—	116	6.5	Butyl Carbitol acetate	4
Glycol diacetate	$C_6H_{10}O_4$ $CH_3COOCH_2CH_2OCOCH_3$	146	1.106	1.4150	0.38	190.5	−31	104	16.44	—	4
Cyclohexyl acetate	$C_8H_{14}O_2$ $CH_2CH_2CH_2CH_2CH_2CHOCOCH_3$	142	0.970	1.440	—	177	−65	64	Insoluble	Hexalin acetate	7
p-tert-Amyl phenyl acetate	$C_{13}H_{18}O_2$ $C_5H_{11}C_6H_4OCOCH_3$	206	0.996	—	—	253–272	6	—	—	—	16
n-Butyl propionate	$C_7H_{14}O_2$ $CH_3CH_2COOC_4H_9$	130	0.870	1.3982@ 25°	—	145.4	−89	40	—	—	10, 19
iso-Butyl propionate	$C_7H_{14}O_2$ $CH_3CH_2COOCH_2CH(CH_3)_2$	130	0.869	1.3975	—	136.8	−71.4	36	0.17	—	7
Amyl propionate	$C_8H_{16}O_2$ $CH_3CH_2COOC_5H_{11}$	144	0.871	1.404	—	160–166	—	41	—	—	19
Amyl butyrate	$C_9H_{18}O_2$ $C_3H_7COOC_5H_{11}$	158	0.862	1.4110	—	163–185	−73.2	—	0.054 @50°	—	16
Amyl laurate	$C_{17}H_{34}O_2$ $C_{11}H_{23}COOC_5H_{11}$	270	0.858	—	—	290–365	—	—	—	—	16
Amyl oleate	$C_{23}H_{44}O_2$ $C_{17}H_{33}COOC_5H_{11}$	352	0.862	—	—	200–240 @20 mm.	—	—	—	—	16
Methyl lactate	$C_4H_8O_3$ $CH_3CHOHCOOCH_3$	104	1.092	1.4131	—	144.8	—	52	∞	—	5
Ethyl lactate	$C_5H_{10}O_3$ $CH_3CHOHCOOC_2H_5$	118	1.031	1.4118	6	154	—	54	∞	—	2, 5, 19
Butyl lactate	$C_7H_{14}O_3$ $CH_3CHOHCOOC_4H_9$	146	0.979	1.4216	—	188	−43	71	3.3	—	5
Amyl lactate	$C_8H_{16}O_3$ $CH_3CHOHCOOC_5H_{11}$	160	0.960	—	—	75–150 @20 mm.	—	—	—	—	16
Ethyl crotonate	$C_6H_{10}O_2$ $CH_3CH{=}CHCOOC_2H_5$	114	0.919	1.4242	—	139	—	2	Insoluble	—	12
Butyl crotonate	$C_8H_{14}O_2$ $CH_3CH{=}CHCOOC_4H_9$	142	0.902	—	—	180–185	—	—	—	—	12
Amyl benzoate	$C_{12}H_{16}O_2$ $C_6H_5COOC_5H_{11}$	192	0.988	1.494	—	261	—	—	—	—	16
Amyl nitrate	$C_5H_{11}O_3N$ $C_5H_{11}ONO_2$	133	1.000	—	—	145–156	—	—	—	—	16
Ethyl borate	$C_6H_{15}O_3B$ $(C_2H_5O)_3B$	146	0.864	1.3731	—	120.0	−86.6	18	De-composes	Triethyl borate	4, 5
Butyl borate	$C_{12}H_{27}O_3B$ $(C_4H_9O)_3B$	230	0.858	1.4091	—	225–230	<−65	87.5	De-composes	—	5
Amyl borate	$C_{15}H_{33}O_3B$ $(C_5H_{11}O)_3B$	272	0.845	—	—	254–255	—	—	De-composes	Triamyl borate	16
ETHERS											
Ethyl ether	$C_4H_{10}O$ $C_2H_5OC_2H_5$	74	0.714	1.3542@ 17.1°	442	34.5	−116.2	−40	6.89	—	4, 19
iso-Propyl ether	$C_6H_{14}O$ $(CH_3)_2CHOCH(CH_3)_2$	102	0.726	—	118	68.4	−60	−9	1.22	—	4
Butyl ether	$C_8H_{18}O$ $C_4H_9OC_4H_9$	130	0.770	1.3992	6.35	142.4	−96	38	<0.05	—	4, 5
Amyl ether	$C_{10}H_{22}O$ $C_5H_{11}OC_5H_{11}$	159	0.80–0.81	1.4212	0.67	170–190	<−75	66	Insoluble	—	16
Amyl phenyl ether	$C_{11}H_{16}O$ $C_5H_{11}OC_6H_5$	164	0.924	—	—	214–229	—	—	—	—	16
Amyl tolyl ether	$C_{12}H_{18}O$ $C_5H_{11}OC_6H_4CH_3$	178	0.916	—	—	227–264	—	—	—	—	16

Ethylene glycol monoethyl ether acetate	$C_6H_{12}O_3$ $CH_3COOCH_2CH_2OC_2H_5$	132	0.975	—	1.09	156.3	—	60	23.0	Cellosolve acetate	4
Diethylene glycol monomethyl ether acetate	$C_7H_{14}O_4$ $CH_3COOC_2H_4OC_2H_4OCH_3$	162	1.040	—	0.12	209.1	—	82	∞	Methyl Carbitol acetate	4
Diethylene glycol monoethyl ether acetate	$C_8H_{16}O_4$ $CH_3COOC_2H_4OC_2H_4OC_2H_5$	176	1.011	—	0.15	217.7	—	110	∞	Carbitol acetate	4
Diethylene glycol monobutyl ether acetate	$C_{10}H_{20}O_4$ $CH_3COOC_2H_4OC_2H_4OC_4H_9$	204	0.981	—	0.04	246.4	—	116	6.5	Butyl Carbitol acetate	4
Glycol diacetate	$C_6H_{10}O_4$ $CH_3COOCH_2CH_2OCOCH_3$	146	1.106	1.4150	0.38	190.5	−31	104	16.44	—	4
Cyclohexyl acetate	$C_8H_{14}O_2$ $CH_2CH_2CH_2CH_2CH_2CHOCOCH_3$	142	0.970	1.440	—	177	−65	64	Insoluble	Hexalin acetate	7
p-tert-Amyl phenyl acetate	$C_{13}H_{18}O_2$ $C_5H_{11}C_6H_4OCOCH_3$	206	0.996	—	—	253–272	6	—	—	—	16
n-Butyl propionate	$C_7H_{14}O_2$ $CH_3CH_2COOC_4H_9$	130	0.870	1.3982@ 25°	—	145.4	−89	40	—	—	10, 19
iso-Butyl propionate	$C_7H_{14}O_2$ $CH_3CH_2COOCH_2CH(CH_3)_2$	130	0.869	1.3975	—	136.8	−71.4	36	0.17	—	7
Amyl propionate	$C_8H_{16}O_2$ $CH_3CH_2COOC_5H_{11}$	144	0.871	1.404	—	160–166	—	41	—	—	19
Amyl butyrate	$C_9H_{18}O_2$ $C_3H_7COOC_5H_{11}$	158	0.862	1.4110	—	163–185	−73.2	—	0.054 @50°	—	16
Amyl laurate	$C_{17}H_{34}O_2$ $C_{11}H_{23}COOC_5H_{11}$	270	0.858	—	—	290–365	—	—	—	—	16
Amyl oleate	$C_{23}H_{44}O_2$ $C_{17}H_{33}COOC_5H_{11}$	352	0.862	—	—	200–240 @20 mm.	—	—	—	—	16
Methyl lactate	$C_4H_8O_3$ $CH_3CHOHCOOCH_3$	104	1.092	1.4131	—	144.8	—	52	∞	—	5
Ethyl lactate	$C_5H_{10}O_3$ $CH_3CHOHCOOC_2H_5$	118	1.031	1.4118	6	154	—	54	∞	—	2, 5, 19
Butyl lactate	$C_7H_{14}O_3$ $CH_3CHOHCOOC_4H_9$	146	0.979	1.4216	—	188	−43	71	3.3	—	5
Amyl lactate	$C_8H_{16}O_3$ $CH_3CHOHCOOC_5H_{11}$	160	0.960	—	—	75–150 @20 mm.	—	—	—	—	16
Ethyl crotonate	$C_6H_{10}O_2$ $CH_3CH{=}CHCOOC_2H_5$	114	0.919	1.4242	—	139	—	2	Insoluble	—	12
Butyl crotonate	$C_8H_{14}O_2$ $CH_3CH{=}CHCOOC_4H_9$	142	0.902	—	—	180–185	—	—	—	—	12
Amyl benzoate	$C_{12}H_{16}O_2$ $C_6H_5COOC_5H_{11}$	192	0.988	1.494	—	261	—	—	—	—	16
Amyl nitrate	$C_5H_{11}O_3N$ $C_5H_{11}ONO_2$	133	1.000	—	—	145–156	—	—	—	—	16
Ethyl borate	$C_6H_{15}O_3B$ $(C_2H_5O)_3B$	146	0.864	1.3731	—	120.0	−86.6	18	Decomposes	Triethyl borate	4, 5
Butyl borate	$C_{12}H_{27}O_3B$ $(C_4H_9O)_3B$	230	0.858	1.4091	—	225–230	<−65	87.5	Decomposes	—	5
Amyl borate	$C_{15}H_{33}O_3B$ $(C_5H_{11}O)_3B$	272	0.845	—	—	254–255	—	—	Decomposes	Triamyl borate	16
ETHERS											
Ethyl ether	$C_4H_{10}O$ $C_2H_5OC_2H_5$	74	0.714	1.3542@ 17.1°	442	34.5	−116.2	−40	6.89	—	4, 19
iso-Propyl ether	$C_6H_{14}O$ $(CH_3)_2CHOCH(CH_3)_2$	102	0.726	—	118	68.4	−60	−9	1.22	—	4
Butyl ether	$C_8H_{18}O$ $C_4H_9OC_4H_9$	130	0.770	1.3992	6.35	142.4	−96	38	<0.05	—	4, 5
Amyl ether	$C_{10}H_{22}O$ $C_5H_{11}OC_5H_{11}$	159	0.80–0.81	1.4212	0.67	170–190	<−75	66	Insoluble	—	16
Amyl phenyl ether	$C_{11}H_{16}O$ $C_5H_{11}OC_6H_5$	164	0.924	—	—	214–229	—	—	—	—	16
Amyl tolyl ether	$C_{12}H_{18}O$ $C_5H_{11}OC_6H_4CH_3$	178	0.916	—	—	227–264	—	—	—	—	16
Amyl xylyl ether	$C_{13}H_{20}O$ $C_5H_{11}OC_6H_3(CH_3)_2$	192	0.907	—	—	250–263	—	—	—	—	16
p-tert-Amyl phenyl *n*-amyl ether	$C_{16}H_{27}O$ $CH_3CH_2CH(CH_3)_2C_6H_4OC_5H_{11}$	234	0.905	—	—	285–295	—	—	—	—	16
Dioxolane	$C_3H_6O_2$ $OCH_2CH_2OCH_2$	74	1.065	—	70	74–75	—	2	∞	—	4
Methyl dioxolane	$C_4H_8O_2$ $OCH_2CH_2OCH(CH_3)$	88	0.982	—	—	81–82	—	—	59.0	—	4
Dioxane	$C_4H_8O_2$ $OCH_2CH_2OCH_2CH_2$	88	1.034	1.4232	29.5	101.1	11.7	18	∞	1,4-Diethylene oxide	4
Dimethyl dioxane	$C_6H_{12}O_2$ $OCH(CH_3)CH_2OCH_2CH(CH_3)$	116	0.927	—	15.4	117.5	—	24	4.33	—	4
Ethylene glycol monomethyl ether	$C_3H_8O_2$ $CH_3OCH_2CH_2OH$	76	0.966	1.4025@ 25°	8.0	125.0	—	46	∞	Methyl Cellosolve	4
Ethylene glycol monoethyl ether	$C_4H_{10}O_2$ $C_2H_5OCH_2CH_2OH$	90	0.931	1.4042@ 25°	4.9	135.1	—	54	∞	Cellosolve	4
Ethylene glycol diethyl ether	$C_6H_{14}O_2$ $C_2H_5OCH_2CH_2OC_2H_5$	118	0.842	1.3914	12.0	121.4	—	35	21	Diethyl Cellosolve	4
Ethylene glycol monobutyl ether	$C_6H_{14}O_2$ $C_4H_9OCH_2CH_2OH$	118	0.902	1.4177@ 25°	0.97	171.2	—	74	∞	Butyl Cellosolve	4
Ethylene glycol monophenyl ether	$C_8H_{10}O_2$ $C_6H_5OCH_2CH_2OH$	138	1.109	—	0.03	244.7	—	121	2.67	Phenyl Cellosolve	4
Ethylene glycol monobenzyl ether	$C_9H_{12}O_2$ $C_6H_5CH_2OCH_2CH_2OH$	152	1.070	—	0.02	255.9	—	129	0.43@23°	Benzyl Cellosolve	4
Diethylene glycol monomethyl ether	$C_5H_{12}O_3$ $CH_3OCH_2CH_2OCH_2CH_2OH$	120	1.035	—	0.2	193.2	—	93	∞	Methyl Carbitol	4
Diethylene glycol monoethyl ether	$C_6H_{14}O_3$ $C_2H_5OCH_2CH_2OCH_2CH_2OH$	134	0.990	1.3274	0.22	201.9	—	99	∞	Carbitol	4
Diethylene glycol diethyl ether	$C_8H_{18}O_3$ $C_2H_5OC_2H_4OC_2H_4OC_2H_5$	162	0.909	—	0.50	187.9	—	82	∞	Diethyl Carbitol	4
Diethylene glycol monobutyl ether	$C_8H_{18}O_3$ $C_4H_9OC_2H_4OC_2H_4OH$	162	0.956	1.4190@ 25°	0.06	230.7	−16	116	∞	Butyl Carbitol	4

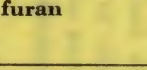
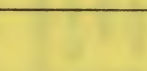
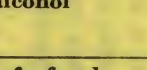
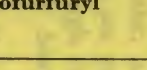
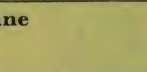
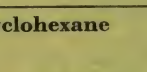
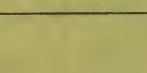
List of Manufacturers of Solvents and Plasticizers

1. Amecco Chemicals, Inc., 75 Rockwood Street, Rochester, N. Y.
2. American Cyanamid and Chemical Corp., 30 Rockefeller Plaza, New York, N. Y.
3. Barrett Company, 40 Rector Street, New York, N. Y.
4. Carbide and Carbon Chemicals Corp., 30 East 42nd Street, New York, N. Y.
5. Commercial Solvents Corp., Terre Haute, Ind.
6. Dow Chemical Co., Midland, Mich.
7. E. I. du Pont de Nemours and Co., Wilmington, Del.
8. Eastman Kodak Co., Chemical Sales Div., Rochester, N. Y.
9. Hercules Powder Co., Wilmington, Del.
10. Kessler Chemical Corp., 239 Eleventh Ave., New York, N. Y.
11. Monsanto Chemical Co., St. Louis, Missouri
12. Niacet Chemicals Corp., Niagara Falls, N. Y.
13. Ohio-Apex, Incroporated, Nitro, West Virginia
14. Charles Pfizer and Co., Inc., 11 Bartlett Street, Brooklyn, N. Y.
15. Resinous Products and Chemical Co., Inc., 222 W. Washington Sq., Philadelphia, Pa.
16. Sharples Solvents Corp., 23rd and Westmoreland Sts., Philadelphia, Pa.
17. Standard Oil Co. of New Jersey, New York, N. Y.
18. The Quaker Oats Co., Chicago, Ill.
19. U. S. Industrial Chemicals, Inc., 60 East 42nd St., New York, N. Y.

NOTE. The second part of this chart follows immediately in back of this page. The Plasticizers Chart may be found opposite page 448.

ALCOHOLS
AMIDES and AMINES
ESTERS
ETHERS

Continuation of Solvents Chart - 1941

NAME	FORMULAS Empirical and Structural	Molecular Weight	Specific Gravity at 20°C	Refractive Index at 20°C	Vapor Pressure at 20°C	Boiling Point	Melting Point	Flash Point (Cleveland Open Cup	Solubility in Water	Common or Trade Names	Manufacturer (See list at bottom of page for key to number)
FURANS					mm. Hg	°C	°C	°C	% by wt.		
Dimethyl furan	C_6H_8O 	96	0.890	1.4363	—	94	—	7	Insoluble	Dimethyl furane	4
Furfural	$C_5H_4O_2$ 	96	1.160	1.5261	8@40°	161.7	−38.7	56	7.7	Furfurol Furfuraldehyde	18
Furfuryl alcohol	$C_5H_6O_2$ 	98	1.133	1.4870	—	169	—	75	∞	Furyl carbinol	18
Tetrahydrofurfuryl alcohol	$C_5H_{10}O_2$ 	102	1.055	1.4519	—	170–178	—	75	∞	—	18
GLYCOLS											
Ethylene glycol	$C_2H_6O_2$ $HOCH_2CH_2OH$	62	1.116	1.4274	0.12	197.2	−17.4	116	∞	—	4
1,2-Propylene glycol	$C_3H_8O_2$ $CH_3CHOHCH_2OH$	76	1.038	—	0.18	188.2	—	107	∞	—	4
1,3-Butylene glycol	$C_4H_{10}O_2$ $CH_3CHOHCH_2CH_2OH$	90	1.006	—	0.05	206.5	—	121	∞	—	4
Decylene glycol	$C_{10}H_{22}O_2$ $CH_3CHOHC(C_2H_5)(C_4H_9)CH_2OH$	174	0.945	—	<0.1	130@3 mm.	—	<121	Slightly soluble	—	4
Diethylene glycol	$C_4H_{10}O_3$ $HOCH_2CH_2OCH_2CH_2OH$	106	1.118	1.446	0.01	244.8	−10.5	143	∞	—	4
Dipropylene glycol	$C_6H_{14}O_3$ $CH_3CHOHCH_2OCH_2CHOHCH_3$	134	1.025	—	0.03	231.8	—	138	∞	—	4
Triethylene glycol	$C_6H_{14}O_4$ $HOC_2H_4OC_2H_4OC_2H_4OH$	150	1.125	—	<0.01	287.3	−5	166	∞	—	4
Tetraethylene glycol	$C_8H_{18}O_5$ $HOC_2H_4OC_2H_4OC_2H_4OCH_2OH$	194	1.125	—	<0.001	327.3	—	174	∞	—	4
Dimethoxytetraglycol	$C_{10}H_{22}O_5$ $(CH_3OC_2H_4OC_2H_4)_2$	222	1.013	—	<0.01	275.8	—	141	∞	—	4
HALOGENATED COMPOUNDS											
n-Butyl chloride	C_4H_9Cl $CH_3CH_2CH_2CH_2Cl$	92.5	0.884	1.4015	—	77.9	−123.1	<4	0.07@12.5°	1-Chlorobutane	16
n-Amyl chloride	$C_5H_{11}Cl$ $CH_3CH_2CH_2CH_2CH_2Cl$	106.5	0.885	1.4119	—	108.2	−99	9	Insoluble	—	16
n-Hexyl chloride	$C_6H_{13}Cl$ $CH_3CH_2CH_2CH_2CH_2CH_2Cl$	120.5	0.877	1.4194	—	132.4	−83	—	Insoluble	—	16
sec-Octyl chloride	$C_8H_{17}Cl$ $CH_3CH_2CH_2CH_2CH(C_2H_5)CH_2Cl$	124.5	0.834	—	—	181–200	—	—	Insoluble	2-Ethylhexyl chloride	16
Ethylene dibromide	$C_2H_4Br_2$ $BrCH_2CH_2Br$	188	2.172@ 25°	1.5379	—	131.4	9.3	None	0.43@25°	—	6
Ethylene dichloride	$C_2H_4Cl_2$ $ClCH_2CH_2Cl$	99	1.256	1.4443	61.1	83.6	−35.3	21	0.86	—	4, 6
Propylene dichloride	$C_3H_6Cl_2$ $CH_3CHClCH_2Cl$	113	1.159	1.4388	37.5	95.9	<−70	21	0.3	1,2-Dichloropropane	4, 6
1,3-Dichloropropane	$C_3H_6Cl_2$ $ClCH_2CH_2CH_2Cl$	113	1.177@ 25°	—	—	120.4	—	—	0.3@30°	—	16
Dichloropentane	$C_5H_{10}Cl_2$ Mixed isomers	141	1.06–1.10	—	—	130–200	—	41	Insoluble	—	16
Chloroform	$CHCl_3$	119.5	1.477	1.4422@ 25°	160	61.2	−63.5	None	0.8	—	6
1,1,2-Trichlorethane	$C_2H_3Cl_3$ $CHCl_2CH_2Cl$	133.5	1.443	1.4711	—	113.5	−36.7	None	Insoluble	—	6
Carbon tetrachloride	CCl_4	154	1.595	1.4607	89.5	76.8	−23	None	0.08	—	6
1,1,2,2-Tetrachlorethane	$C_2H_2Cl_4$ $CHCl_2CHCl_2$	168	1.600	1.4942	11	146.5	−43.8	None	Insoluble	—	6
Trichlorethylene	C_2HCl_3 $ClCH=CCl_2$	131.5	1.466	1.4777	56	87	−86	None	0.1	—	4, 6
Perchlorethylene	C_2Cl_4 $Cl_2C=CCl_2$	166	1.624	1.5055	17	121	−22.4	None	Insoluble	—	6
Ethylene chlorhydrin	C_2H_5OCl $HOCH_2CH_2Cl$	80.5	1.205	1.442	5.8	128.7	−69	60	∞	β-Chloroethyl alcohol	4
Propylene chlorhydrin	$CH_3CHOHCH_2Cl$ C_3H_7OCl	94.5	1.113	—	6.87	127.4	—	52	∞	—	4
Chloracetyl chloride	$C_2H_2OCl_2$ $ClCH_2COCl$	113	1.498	—	15.0	105	—	None	Decomposes	—	4
Dichlorethyl ether	$C_4H_8OCl_2$ $ClCH_2CH_2OCH_2CH_2Cl$	143	1.222	1.457	1.0	178.5	−50	85	1.07	—	4
Dichlor-*iso*-propyl ether	$C_6H_{12}OCl_2$ $CH_3CH(CH_2Cl)OCH(CH_2Cl)CH_3$	171	1.112	—	0.85	187.3	—	85	0.17	—	4
Triglycol dichloride	$C_6H_{12}O_2Cl_2$ $ClCH_2CH_2OCH_2CH_2OCH_2CH_2Cl$	187	1.197	—	0.06	241.3	—	121	1.89	—	4
Tetraglycol dichloride	$C_8H_{16}O_3Cl_2$ $(ClCH_2CH_2OCH_2CH_2)_2O$	231	1.186	—	<0.1	114@2 mm.	—	>121	Slightly soluble	—	4
Monochlorbenzene	C_6H_5Cl	112.5	1.107	1.5248	9	131.6	−45	27	0.049@30°	—	6
o-Dichlorbenzene	$C_6H_4Cl_2$	147	1.305	1.5485	—	180.2	−18.3	68	0.008@25°	—	6
Trichlorbenzene	$C_6H_3Cl_3$ 1,2,3 and 1,2,4 isomers	133.5	1.460@ 25°	1.5700@ 25°	—	214.8	7.5	100	Insoluble	—	6
Amyl chlornaphthalene	$C_{15}H_{17}Cl$ $C_5H_{11}C_{10}H_6Cl$	232.5	1.076	—	—	208–230@ 25 mm.	—	—	—	—	16
HYDROCARBONS											
Amylene	C_5H_{10} Mixed isomers	70	0.66	—	—	32–45	−139	—	Insoluble	—	16
Diamylene	$C_{10}H_{20}$ Synthetic mixed isomers	140	0.775	—	—	150–170	—	—	Insoluble	—	16
Cyclohexane	C_6H_{12} 	84	0.779	1.4290@ 15°	—	81.4	6.5	—	Insoluble	—	8
Methyl cyclohexane	C_7H_{14} 	98	0.769	1.4235	—	100.3	−126.4	—	Insoluble	—	8
Benzene	C_6H_6 	78	0.879	1.5017	—	80.2	5.5	−8	0.08	Benzol	3
Toluene	C_7H_8 $C_6H_5CH_3$	92	0.866	1.4962	36.7@ 30°	110.4	−95	6.5	0.05	Methyl benzene	3
Xylene Ortho	C_8H_9 $C_6H_5(CH_3)_2$	106	0.879	1.5058	10	144	−27.1	29	Insoluble	Dimethyl benzene	3
Xylene Meta			0.865	1.4973	6.4	139	−53.6	—			
Xylene Para			0.861	1.4956	16.4	138	13.2	—			
Ethyl benzene	C_8H_{10} $C_6H_5CH_2CH_3$	106	0.870	1.4959	15.3	135.7	−93	29	0.01	—	4, 6
iso-Propyl benzene	C_9H_{12} $C_6H_5CH(CH_3)_2$	120	0.862	1.4930	11.8	152.5	−97	54	Insoluble	Cumene	4, 6
Diethyl benzene	$C_{10}H_{14}$	134	0.868	1.493@	—	181.2	<−70	59	Insoluble	75–80% ortho	6

Para	$C_8H_5(CH_3)_2$		0.865	1.4973	6.4	139	−53.6	—	Insoluble	Dimethyl benzene	3
Ethyl benzene	C_8H_{10} $C_6H_5CH_2CH_3$	106	0.861 0.870	1.4956 1.4959	16.4 15.3	138 135.7	13.2 −93	— 29	Insoluble 0.01	— —	3 4, 6
iso-Propyl benzene	C_9H_{12} $C_6H_5CH(CH_3)_2$	120	0.862	1.4930	11.8	152.5	−97	54	Insoluble	Cumene	4, 6
Diethyl benzene	$C_{10}H_{14}$ $C_6H_4(C_2H_5)_2$	134	0.868	1.493@ 25°	—	181.2	<−70	59	Insoluble	75–80% ortho 20–25% meta	6
Amyl benzene	$C_{11}H_{16}$ $C_6H_5C_5H_{11}$	148	0.874	1.4751@ 15°	—	202	−78	—	Insoluble	—	16
Diamyl benzene	$C_{16}H_{26}$ $C_6H_4(C_5H_{11})_2$	218	0.868	—	—	255–280	<−75	—	Insoluble	—	16
Dibenzyl	$C_{14}H_{14}$ $C_6H_5CH_2CH_2C_6H_5$	182	0.942@ 81°	1.539@ 81°	—	284	52.5	—	Insoluble	—	4
Tetrahydronaphthalene	$C_{10}H_{12}$ $CH_2CH_2CH_2CH_2C{=}CCH{=}CHCH{=}CH$	132	0.971	1.5461	26.3@ 100°	207	−30	80	Insoluble	Tetralin	7
Decahydronaphthalene	$C_{10}H_{18}$ $CH_2CH_2CH_2CH_2CHCHCH_2CH_2CH_2CH_2$	138	0.895	1.4828	—	193	−65	57	Insoluble	Decalin	7
Petroleum ether	Mainly hexanes	—	0.63–0.67	1.365–1.376	—	40–60	<−73	<0	Insoluble	Light ligroin	17
Gasoline	Hexanes, heptanes, and some pentanes and octanes	—	0.66–0.684	1.375–1.388	—	60–120	−90 to −96	−23 to 4	Insoluble	Benzine Third fraction of petroleum	17
Ligroin	Hexanes, heptanes, and octanes	—	0.73	1.407–1.425	—	80–130	—	—	Insoluble	Petroleum spirit Petroleum naphtha	17
V. M. & P. Naphtha		—	0.75–0.77	1.41	—	100–160	<−46	−7 to 10	Insoluble	Varnish Makers' and Painters' Naphtha	17
Mineral spirit		—	0.77–0.80	1.42	—	150–200	<−46	30–40	Insoluble	Heavy naphtha	17
Stoddard solvent		—	0.78–0.79	—	—	155–190	<−46	39	Insoluble	White spirits Naphtha safety solvent	17
Kerosene		—	0.81–0.82	1.45	—	150–250	—	66	Insoluble	Fifth fraction of petroleum	17
Turpentine	Terpenes, terpinenes, borneol, fenchyl alcohol, limonene, trace of camphor	—	0.860–0.875	1.465–1.478	—	150–160	—	34	Insoluble	Gum turpentine Gum spirits Spirit or oil of turpentine	9
Wood turpentine	Mainly alpha pinene and dipentene	—	0.860–0.875	1.465–1.478	—	150–160	—	34	Insoluble	Steam distilled wood turpentine	9
Dipentene (dipentine)	$C_{10}H_{16}$	—	0.845–0.854	1.472–1.477	—	170–188	—	—	Insoluble	Sources: Wood turpentine or camphor synthesis by-product	9
Pine oil	Terpene hydrocarbons, alcohols and ketones	—	0.93–0.94	1.479	—	200–230	—	—	Insoluble	Herco Pine Oil	9
Solvenol No. 1	Dipentene, pinene, terpeneol, fenchene, paramenthane, cymene and terpinoline	—	0.85–0.86	1.470–1.478	—	165–212	—	43	Insoluble	Refined pine oil	9
Hercosol No. 80	Terpene hydrocarbons, alcohols, and ketones	—	0.895–0.905	1.4763	—	174–225	—	145	Insoluble	Refined pine oil	9
Solvent naphtha		—	0.850–0.870 @15.5°	—	—	130–155	—	27–29	Insoluble	—	3
Light solvent naphtha	Mainly trimethyl and tetramethyl benzene with other alkyl substituted benzenes and some naphthalene	—	0.860–0.885 @15.5°	—	—	130–180	—	27–32	Insoluble	Hi-Flash naphtha	3
Heavy solvent naphtha	Light solvent naphtha components plus coumarone, indene, styrene, methyl naphthalene, etc.	—	0.885–0.970 @15.5°	—	—	150–220	—	<38	Insoluble	—	3
KETONES											
Acetone	C_3H_6O CH_3COCH_3	58	0.791	1.3591	178	56.1	−95	−18	—	—	4, 5, 10 11, 19
Methyl ethyl ketone	C_4H_8O $CH_3COCH_2CH_3$	72	0.805	1.3807	77.5	79.6	−86	−14	26	—	10
Methyl *iso*-butyl ketone	$C_6H_{12}O$ $CH_3COCH_2CH(CH_3)_2$	100	0.802	1.3959	18.1	116.0	−85	24	1.98	—	4
Methyl *n*-amyl ketone	$C_7H_{14}O$ $CH_3COCH_2CH_2CH_2CH_2CH_3$	114	0.817	—	3.53	150.6	—	49	0.43	—	4
Di-*n*-propyl ketone	$C_7H_{14}O$ $CH_3CH_2CH_2COCH_2CH_2CH_3$	114	0.816	1.4073@ 21.7°	5.2	143.7	−32.6	41	0.43	Butyrone	4
Di-*iso*-butyl ketone	$C_9H_{18}O$ $(CH_3)_2CHCH_2COCH_2CH(CH_3)_2$	142	0.809	1.412@ 21°	1.7	168.1	—	60	<0.06	—	4
Mesityl oxide	$C_6H_{10}O$ $(CH_3)_2C{=}CHCOCH_3$	98	0.857	1.4558	9.23	128.7	−59	32	2.78	—	4, 5
Phorone	$C_9H_{14}O$ $(CH_3)_2C{=}CHCOCH{=}C(CH_3)_2$	138	0.879	1.4998	0.38	197.9	28	85	0.11@50°	—	4
Cyclohexanone	$C_6H_{10}O$ $CH_2CH_2CH_2CH_2CH_2CO$	98	0.948	1.4507	—	156.7	−45	50	5	—	7
Methyl cyclohexanone	$C_7H_{12}O$ $CH_3CHCH_2CH_2CH_2CH_2CO$	112	0.920	1.4505@ 14.6°	—	163	−70	53	3	—	7
Isophorone	$C_9H_{14}O$ $COCH{=}C(CH_3)CH_2C(CH_3)_2CH_2$	138	0.923	—	0.31	215.2	—	96	—	—	4
Acetonyl acetone	$C_6H_{10}O_2$ $CH_3COCH_2CH_2COCH_3$	114	0.974	1.449	0.68	191.4	−9	85	∞	—	4
Diacetone alcohol	$C_6H_{12}O_2$ $(CH_3)_2COHCH_2COCH_3$	116	0.941	1.4210	1.47	167.9	−55	77	∞	—	4
NITROHYDROCARBONS											
Nitromethane	CH_3O_2N CH_3NO_2	61	1.139@ 20°	1.3818@ 20°	—	101	—	35[a]	5.4	—	5
Nitroethane	$C_2H_5O_2N$ $CH_3CH_2NO_2$	75	1.052@ 20°	1.3916@ 20°	—	114	—	27[a]	3.3	—	5
1-Nitropropane	$C_3H_7O_2N$ $CH_3CH_2CH_2NO_2$	89	1.003@ 20°	1.4015@ 20°	—	132	—	33[a]	1.3	—	5
2-Nitropropane	$C_3H_7O_2N$ $CH_3CHNO_2CH_3$	89	0.992@ 20°	1.3941@ 20°	—	120	—	24[a]	1.8	—	5
1-Nitrobutane	$C_4H_9O_2N$ $CH_3CH_2CH_2CH_2NO_2$	103	0.975@ 20°	1.4112@ 20°	—	152	—	46[a]	0.5	—	5
2-Nitrobutane	$C_4H_9O_2N$ $CH_3CH_2CHNO_2CH_3$	103	0.968@ 20°	1.4036@ 20°	—	139	—	36[a]	0.9	—	5
SULFUR DERIVATIVES											
Carbon bisulfide	CS_2	76	1.263	1.6232@ 25°	127@0°	46.3	−109	<4	0.22@22°	—	6

[a] Tagliabue open cup.

NOTE. The first part of the chart immediately preceeds this page. The Plasticizers Chart will be found opposite page 448.

Additional copies of this chart may be purchased from the publisher—Address MODERN PLASTICS, 122 E. 42nd St., New York, N. Y.

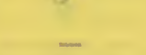
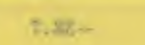
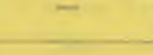
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List of Manufacturers of Solvents and Plasticizers

1. Amecco Chemicals, Inc., 75 Rockwood Street, Rochester, N. Y.
2. American Cyanamid and Chemical Corp., 30 Rockefeller Plaza, New York, N. Y.
11. Monsanto Chemical Co., St. Louis, Missouri
12. Niacet Chemicals Corp., Niagara Falls, N. Y.
13. Ohio-Apex, Incorporated, Nitro, West Virginia

Furans Glycols
Halogenated Compounds

Continuation of Solvents Chart - 1941

NAME	FORMULAS Empirical and Structural	Molecular Weight	Specific Gravity at 20°C	Refractive Index at 20°C.	Vapor Pressure at 20°C.	Boiling Point	Melting Point	Flash Point (Closed Cup Open Cup)	Solubility in Water	Common or Trade Names	Literature Reference (See list at bottom of page for key to numbering)
ETHERS					mm. Hg	°C	°C	°C	% by wt.		
Dimethyl furan	C_6H_8O 	96	0.850	1.4362	—	94	—	7	Insoluble	Dimethyl furane	4
Furfural	$C_5H_4O_2$ 	96	1.160	1.5261	8@40°	161.7	-38.7	56	7.7	Furfural Furfuraldehyde	18
Furfuryl alcohol	$C_5H_6O_2$ 	98	1.132	1.4870	—	169	—	75	∞	Furyl carbinol	18
Tetrahydrofurfuryl alcohol	$C_5H_{10}O_2$ 	102	1.055	1.4510	—	170-178	—	75	∞		18
GLYCOLS											
Ethylene glycol	$C_2H_6O_2$ $HOCH_2CH_2OH$	62	1.116	1.4276	0.12	197.2	-17.4	116	∞	—	6
1,2-Propylene glycol	$C_3H_8O_2$ $CH_3CHOHCH_2OH$	76	1.038	—	0.13	188.2	—	107	∞	—	6
1,3-Butylene glycol	$C_4H_{10}O_2$ $CH_3CHOHCH_2CH_2OH$	90	1.006	—	0.05	206.5	—	121	∞	—	6
Isoprene glycol	$C_5H_{12}O_2$ $CH_3CHOHC(CH_3)(C_2H_5)CH_2OH$	104	0.945	—	<0.1	190@5 mm.	—	<121	Slightly soluble	—	6
Diethylene glycol	$C_4H_{10}O_3$ $HOCH_2CH_2OCH_2CH_2OH$	106	1.118	1.446	0.01	244.8	-10.5	143	∞	—	6
Dipropylene glycol	$C_6H_{14}O_3$ $CH_3CHOHCH_2OCH_2CHOHCH_3$	134	1.020	—	0.02	231.8	—	138	∞	—	6
Triethylene glycol	$C_6H_{14}O_4$ $HOC_2H_4OC_2H_4OC_2H_4OH$	150	1.126	—	<0.01	287.3	-5	166	∞	—	6
Tetraethylene glycol	$C_8H_{18}O_5$ $HOC_2H_4OC_2H_4OC_2H_4OC_2H_4OH$	194	1.125	—	<0.001	327.8	—	174	∞	—	6
Dimethoxytetraglycol	$C_{10}H_{22}O_5$ $(CH_3OC_2H_4OC_2H_4)_2O$	222	1.013	—	<0.01	275.6	—	143	∞	—	6
HALOGENATED COMPOUNDS											
n-Butyl chloride	C_4H_9Cl $CH_3CH_2CH_2CH_2Cl$	92.5	0.884	1.4052	—	77.9	-123.1	<4	0.07@12.5°	1-Chlorobutane	16
n-Amyl chloride	$C_5H_{11}Cl$ $CH_3CH_2CH_2CH_2CH_2Cl$	106.5	0.886	1.4119	—	108.2	-99	9	Insoluble	—	16
n-Hexyl chloride	$C_6H_{13}Cl$ $CH_3CH_2CH_2CH_2CH_2CH_2Cl$	120.6	0.877	1.4194	—	132.4	-83	—	Insoluble	—	16
sec-Octyl chloride	$C_8H_{17}Cl$ $CH_3CH_2CH_2CH_2CH(C_2H_5)CH_2Cl$	134.5	0.874	—	—	181-200	—	—	Insoluble	2-Ethylhexyl chloride	16
Ethylene dibromide	$C_2H_4Br_2$ $BrCH_2CH_2Br$	188	2.172@ 25°	1.5376	—	131.6	9.3	None	0.43@25°	—	6
Ethylene dichloride	$C_2H_4Cl_2$ $ClCH_2CH_2Cl$	99	1.256	1.4448	11.1	83.6	-35.5	21	0.85	—	6, 8

Alkyd resins for coatings*

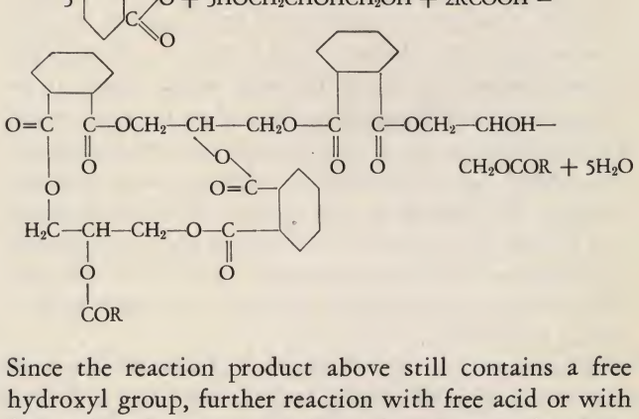
THIS year, hundreds of thousands of motor cars will be finished with the so-called "synthetic enamels," millions of words will be printed with inks made from alkyd resins, and countless other items of everyday use will be protected and beautified with finishes containing, as their bases, alkyd resins. Yet it is rather remarkable to recall that as recently as five years ago, alkyd resins were having a hard time to penetrate the field of surface coatings due to the entrenchment of varnishes and lacquers. This rapid growth in the use of alkyds may be due to several causes—the shortage of tung oil for varnishes, the ease of handling of the alkyds, etc. We prefer to believe that the surface coating industry has come to learn that alkyd resins are superior in such properties as gloss, gloss-retention and flexibility. Despite the lack of water-resistance of early alkyds and their slow drying rates, the earliest workers with these resins realized that they had great potentialities.

One industrial group, which was quick to recognize the advantages of alkyds, was the automotive industry. With characteristic progressiveness, this industry had continued to improve the performance and safety of motor cars, but were at a loss to improve upon the finish until the adoption of alkyd resins as the vehicles for automotive enamels. It is true that the pyroxylin lacquers had advantages in drying speeds. But it is also true that many coats of lacquer had to be applied to obtain the desired effect, and that at best the lacquers were inclined to *chalk*—that is, become dull due to the failure of the binder, leaving the residue of powdery film on the surface. Alkyds were welcomed by the automotive industry because they produced a rich "deep" finish with high luster, which stayed that way.

Alkyds were not long in invading other fields and are now used on innumerable exterior objects—pumps, trucks, signs, etc.—where they perform the two tasks of any surface coating: to protect and to beautify. The metal decorating field is an excellent example. Alkyds fitted right into the picture due to their inherent beauty in enamels, and their excellent baking properties, flexibility, toughness and color retention. A bottle cap is a simple little object which is flipped away as soon as its job of sealing is done. But the manufacture of these from thin sheets of metal makes demands of a finish which are extremely severe. Usually the sheet is coated first with a white enamel base coat, and later printed with other colors. Each color gets a bake, and the alkyd white has to stay *white*. The caps are punched out and the enamel film must be hard enough to resist being cut through and breaking on bending. Sometimes the bottle cap may be threaded and finally it may be subjected to still another processing operation—exposure to hot water or steam. At the end, the finish must be as perfect as it was when first applied to the flat sheet. Consider white metal objects—refrigerators, hospital furniture, washing machines, etc. The finish has to be white, tough, hard and glossy—and remain so for years.

Intelligent consumers know that alkyd resins of a sort can be made in any vessel by heating together phthalic anhydride, glycerine and fatty acids, but they also realize that the best results, and the most distinctive products, are obtained only when the resin reaction is carried out under rigidly controlled conditions, in specially designed equipment. They know that it is necessary to use polyhydric alcohols (alcohols with more than one reactive OH group) and polybasic acids (acids with more than one COOH group) in order to build up complex or resinous structures. Ordinarily, this reaction is modified by the presence of a third component, fatty acid, which not only retards gelatinization, but serves as a plasticizing constituent.

The reaction leading to resin formation is most simply expressed as follows: If RCOOH represents linseed oil fatty acids, the reaction given below may be used to show both the introduction of the oil constituent and the cross linkages between chains, leading to very large molecules of resin.



Since the reaction product above still contains a free hydroxyl group, further reaction with free acid or with free carboxyl groups on other polymers can take place, giving rise to even greater complexity.

Actually, the number of alcohols which can be used is limited. Ethylene glycol has been employed, but, generally speaking, its use is restricted to those resins which are to serve as plasticizers for nitrocellulose, etc., and which are therefore required to be permanently soft and extremely flexible. Glycerol, with its three reactive groups, is the most widely used alcohol, and may

* This article was especially prepared for this issue by Dr. K. E. Martin, Resinous Products & Chemical Co.



1—Duraplex C-49 originally developed for fine decorating work has proven a versatile coating material as on the containers above

be assumed to be present in all those resins which are used alone for air-drying or baking finishes. The higher alcohols, such as sorbitol, mannitol and pentaerythritol, have been investigated, but have not met with wide acceptance due to their tendency to produce resins of poor color retention and low water-proofness.

By far the most widely used polybasic acid is phthalic —available at low cost as the anhydride. It reacts readily to form typical resins, and this ease of reaction, plus its relatively low cost, assures its continued use. Maleic anhydride also is being employed on an increasing scale, although it is more difficult to handle and is more expensive. Maleic, unlike phthalic, has the ability to react with double bonds of unsaturated compounds, as well as with hydroxyl groups in true ester formation. This fact has been employed in the manufacture of high-melting ester gum modifications for lacquers, sanding sealers and some color-retaining varnishes. When combined with oils in the proper way, maleic serves to increase the viscosity rapidly and speed up the drying rate. Other dibasic acids—succinic, maleic, tartaric, sebacic, etc.—have been investigated with limited practical success. In general, as the number of carbon atoms in the dibasic acids increases, so increase the toughness and flexibility of the resultant resins. As a result, the soft, plasticizing types of resins are made from such acids as adipic and sebacic.

With regard to the oil portion of the alkyds, there are many types available. Ordinarily, the oil acids rather than the oils are used. If the oils themselves are employed, they require a heating period with glycerol before resin formation can take place. This relatively simple step—one of alcoholysis—alters the oil molecule, leaving only one or two acid radicals joined to the glycerol, instead of the original three, and increases the compatibility or reactivity of the phthalic, glycerine and oil component. Thereafter, the reaction proceeds in much the same way as if fatty acids are used originally. The properties of the oils show up in the resin. Linseed oil, for example, dries well to hard films, which may be expected to discolor. Tung oil dries fastest to most water-proof films, but is difficult to control when undiluted with other oils. Soybean oil results in slower-drying, softer resins which have superior color retention. Fish oil, used in cheaper alkyds, dries well enough but imparts poor color and odor. Castor oil—widely used—produces two types of resins, one the non-drying plasticizing type and the other, an air-drying type with very desirable properties. In order to make the second type, the non-drying castor oil is dehydrated by a heat treatment, becomes more unsaturated, and thereby acquires drying properties. Other non-drying oils, such as cocoanut oil, are useful in the manufacture of resins which are characterized as being the ultimate in color retention, but require blending with a harder resin, such as a urea-formaldehyde product to provide the necessary drying and hardness.

Of quite as much importance as the choice of materials is their incorporation into the resin in the proper proportions. Although the resins are mixed esters, it is often helpful to speak of the "percent of alkyd in the resin" or the "alkyd portion," as contrasted with the "oil portion." This does not mean that the two portions are separate and distinct; but it is a means of expressing the relative amount of esterified phthalic anhydride in the resin. And this is a most important consideration, because as the amount of the "alkyd portion"—or "alkyd percent"—is varied, so vary the entire properties of the resin. The importance of alkyd percent is well appreciated by manufacturers but is not always understood by the customer. This one factor determines the rate of drying, the durability, the solubility, the compatibility and other properties of the resin.

For each resin there appears to be an optimum range of condensation, as measured by viscosity, within which range the resin will exhibit the best combination of film properties. If the resin is not carried into this range it will dry slowly to soft films having poor water-proofness (due to incomplete esterification), poor adhesion, deficient gloss, and in some cases excessive flow, resulting in sagging, curtaining, etc. If the viscosity is carried too high, the resin will display those properties usually associated with "overbodied varnishes," viz., poor drying, instability to pigments, poor leveling and lowered solubility with a tendency to form gels.

It might be well to list some of the most important film properties of enamels and show how they are affected by the various factors discussed above.

1. Drying.
   (a) Choice of oil.
   (b) Alkyd percent: The higher the alkyd percent, the faster the set, but the slower the through-hardness obtained.
   (c) Viscosity: Higher viscosity results in faster drying, provided the viscosity results from the alkyd portion and not from the polymerization of the oil portion, in which case the drying may be retarded.

(d) Higher temperature of condensation: At the higher temperatures, the viscosity due to phthalic-glycerol reaction is greatest.

2. Taping qualities.
   (a) This results from a hard surface, and is dependent for the most part on the alkyd percent, assuming that the fastest oils are used.

3. Gloss and gloss-retention.
   (a) Higher alkyd percent makes for higher gloss.
   (b) Hazing may be due to ZnO reacting with acids in resins of high acid number.

4. Solubility.
   (a) Alkyd percent: Under 50% alkyd resins are soluble in aliphatic hydrocarbons; above 50% they require aromatic solvents; above 60%, resins require esters.

5. Oil compatibility.
   (a) Alkyd percent: High alkyd percent makes for lower compatibility. There is practically no oil compatibility above 43% alkyd. Under 35% alkyd, resins are practically completely compatible.
   (b) Viscosity: Resins of higher viscosity have lower compatibility.

6. Water resistance.
   (a) Alkyd percent: Lower alkyd percent makes for better resistance.
   (b) Presence of other resinous materials, such as oil-extended phenol-formaldehyde resins, improves water resistance.
   (c) Acid number: Higher acidity indicates incomplete esterification and hence lower water resistance.
   (d) Choice of oil.

7. Color and color retention.
   (a) Oil: Cocoanut best; dehydrated castor, castor, soybean and tung next, in that order; linseed poorest.
   (b) Acid: Maleic serves to improve original color.
   (c) Alkyd percent: Only the oil in the resin discolors, so the more oil, the more discoloration.

8. Pigment stability.
   (a) Acid number: Lower acid number makes for greater stability.
   (b) Alkyd percent: Lower alkyd percent makes for greater stability.
   (c) Viscosity or degree of condensation.
   (d) Processing to insure proper range of particle size.

9. Durability.
   (a) Alkyd per cent: In general the baked films of resins with high alkyd are most durable. The same resins air-dried might have poorest durability.

Water paints, based on proteins such as casein, enjoy a wide adoption due to the fact that they are solvent-free, may be diluted with water and are extremely easy to apply. The paints dry rapidly to films of very pleasing appearance, which, however, are lacking in water resistance, are not sufficiently washable and, of course, cannot be used outdoors. When alkyds are emulsified, the resultant emulsion can be pigmented to produce paints which have the ease of application of ordinary water paints but washability and durability similar to that which we associate with alkyd resins or oil paints. Consequently these alkyd emulsion paints are filling a real need for easily applied protective coatings over plaster and all types of masonry. Ordinarily, they may be applied before the plaster is thoroughly dry, the advantage of which is obvious.

An ever-increasing use of alkyds is in conjunction with urea-formaldehyde type resins for the production of finishes with unusually high gloss, mar resistance and color retention. Oxidizing alkyds may be used to a limited extent due to their lack of color retention on baking. Ordinarily the newer non-drying alkyds of high alkyd percent and excellent color retention are employed.

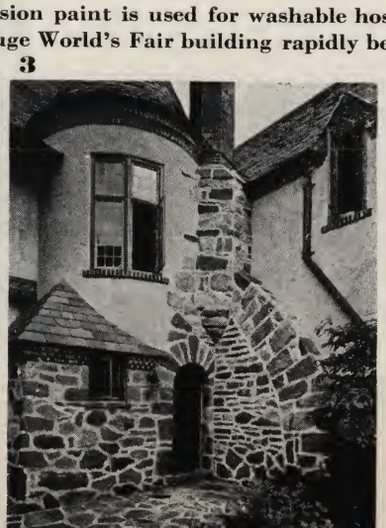
Unquestionably the wide application of alkyds will continue to expand. The trade now appreciates their merits. Continued intelligent utilization of the right resin for the right job—involving a consideration of the factors discussed above—is bound to result in increased consumption. The future will see the production of tailor-made resins, designed to meet the requirements of very specific fields of applications. Improvements—sometimes small—will continue to be made as we learn more of the fundamental facts concerning alkyd resin manufacture and application. One thing is certain—alkyds are going places!

2—Quick drying, odorless Aquaplex resin emulsion paint is used for washable hospital walls. 3—Rough, uneven stucco was made weather resistant and (4) A huge World's Fair building rapidly beautified with this same coating

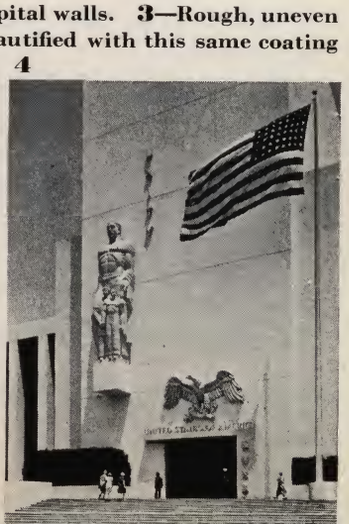
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Phenolic resin coatings

SWEEPING changes have taken place in the manufacture of varnishes. As far as the ultimate consumer is concerned, an enamel brushes and flows the same. There is no difference in color or gloss. Your home would look no different on the inside as far as the finish is concerned than if you used paint of two years ago. But the interior construction of the liquid that binds the pigment together and that allows you to spread the colored pigment over a piece of wood or metal is quite different.

Imported oils and synthetic resins some time ago replaced linseed oil-kauri gum varnishes, and these new oil-resin varnishes came to be used almost exclusively. Then a great flurry of price increases in imported oils took place and we presently found ourselves without any of these oils. The war in the Orient materially cut the supplies. The paint consumer had come to demand four-hour and even one-hour drying enamels that would stand boiling water, strong soaps and detergents. When the enamel manufacturer had to turn to domestic oils, he found that even the newer synthetic resins would not dry the slower, softer domestic oils fast enough nor would the varnishes have sufficient resistance to chemicals.

While the oil refiners set about to improve the dry on their oils if possible, the resin manufacturers produced new resins to meet the demand. The spotlight was focused on phenolic resins because no other resins gave the extreme durability, chemical resistance, toughness, and gloss retention of the phenolics. In order to see what happened inside of the resin as it evolved into the new phenolics we must know the general characteristics of the older types.

Resins of the phenolic type are divided into two general types. In one, a molding compound resin, which is inherently insoluble in drying oils, is dispersed in rosin and advanced or set up. This molding type of resin is so insoluble that only a small amount can be dispersed in oil by a large amount of rosin. Because the proportion of the phenolic content is so small about all that can be said of the resin is that it is very hard. It will impart this hardness to an oil but it is sadly lacking in resistance to boiling water and chemicals because of the large amount of rosin.

The other type of phenolic resin is a pure phenol-formaldehyde resin that is processed in the kettle to make it oil-soluble. Usually this resin will not set up or advance under heat and is permanently fusible. When a varnish is made with this type of resin and a softer, slower drying oil, it has much better water and chemical resistance and durability than any other varnish from linseed oil. However, the varnish dries more slowly than many people are willing to accept.

It would seem, then, that a combination of these two resins should give a compromise that would be quite satisfactory. Fortunately this is the case in many instances and it was by this means that many finishes were converted from tung oil-ester gum varnishes to linseed oil-phenolic resin varnishes with little or no sacrifice in resistance characteristics and performance. However, it is that last few percent of performance needed to give perfection that takes the bulk of the work in any research project.

One manufacturer has produced a series of new resins which seem to be the answer to real fast dry with very good water resistance and hardness when slower drying, softer oils are used. These are called isomerized terpene-phenolic resins. The formaldehyde in a phenol-formaldehyde resin is replaced with various materials of a terpenic nature. A wide range of properties is possible in this type of resin but the ones generally used are very hard and brittle. They have melting points considerably higher than the old fossil gums, after the latter have been rendered oil-soluble, and they dry much more rapidly.

The superiority of these new resins is readily shown by the fact that they can be used in floor varnishes and floor paints where linseed oil is the major oil constituent. If they can be used to make finishes to resist the pound-

1—Corrosion- and weather-resisting paint materials with a Durez phenolic resin base are used successfully in giving a shop coat to this structural steel

1



ing, scuffing, and abrasive action of walking, they can be readily adapted to other finishes where the main requisite is elimination of tackiness and other properties are not so necessary. So we find that they are in great demand in all types of "shelf goods" as the general types of paint and varnish used by Mr. Homeowner are called.

In "industrial finishes," as the types that are applied by spraying, dipping, and roller coating with subsequent baking in an oven are called, we also find an increasing demand for the terpene-phenolics. The industrial finishes were not as hard hit by the lack of imported oils as were the "shelf goods" because the heat of baking will give rapid dry even to the slower oils. However, the same speed of dry that is imparted to the "shelf goods" is also passed on to the "industrial finishes." Lower temperatures can be used in baking ovens, or if high temperatures are used the time of baking can be decreased and production speeded up.

While it is now possible to produce a "four-hour" drying line of finishes it is not possible to equal the "one-hour" air-drying finishes without the use of a large proportion of tung oil. One manufacturer has developed another new type of resin that is proving of real value in very fast air-drying primers. But we do not know of its use in finishes. This new type is known as a "dispersion resin." Essentially, it is made by forming a phenolic resin in the presence of an oil. The dispersion of resin in the oil is marketed as a single compound which may vary in consistency from a taffy-like mass to a brittle solid. The paint manufacturer cuts the resin with fast evaporating thinners, and pigments the solution just as he would a varnish. The pigmented solution is then suitable as a primer for use under lacquer. If the chemical action is carried practically to completion in the basic resin there is no need for further drying. The film is "dry" as soon as the solvent is released. Within a comparatively few minutes a finish coat of lacquer can be applied over the primer and there is no "lifting" of the primer by the solvent action of the lacquer thinners.

Properties of phenolic resin coatings

Phenol-formaldehyde resins are used by the paint and varnish manufacturer to produce the following new properties in his paint films:

Greater speed: The drying time of exterior coatings is reduced from 24 and 48 hours to 4 or 5 hours. Where still greater speed is required, anticorrosive primers may be made to air-dry in one minute.

Durability: In the past the varnish maker depended upon the use of larger proportions of drying oils to increase durability. His higher resin content coatings while harder were poorer in durability. The new phenolic resin, however, reversed this, so that increasing the resin content produced improved hardness and at the same time increased retention of toughness on exposure and resistance to light, air, and water. Varnished panels exposed to atmospheric conditions in Florida show a marked increase in durability between the spar varnishes obtainable in 1928 and the phenolic type of a few years later. In three months' exposure at 45 deg. facing the sun the old-fashioned varnishes based on fossil resins or rosin and ester gum are badly deteriorated. After six months, however, the varnishes made with phenol-formaldehyde resin have not even lost their gloss.



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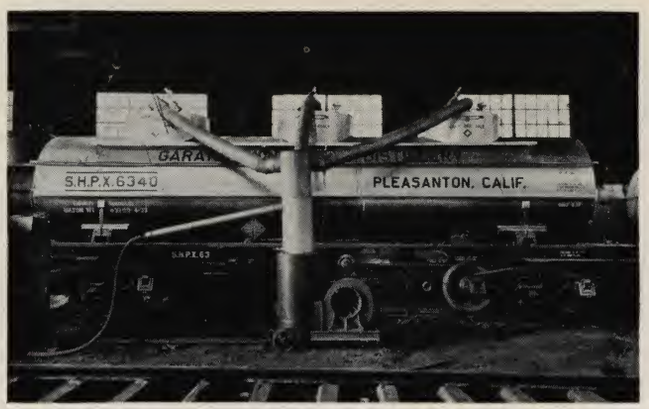


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2—Oil-soluble resins produce high gloss overprint varnishes and finishes for metal signs, and prolong their fresh appearance. 3—This fleet of city trucks is finished with a phenolic resin base aluminum paint. (Photos, courtesy Durez Plastics & Chemicals, Inc.)

Water resistance: Perhaps the most important property of a protective coating is its ability to resist moisture. If it is to protect lumber, then it must resist the absorption of moisture on a wet day, causing swelling, and the subsequent shrinkage on a dry day. This repeated expansion and contraction causes weathering and breakdown in the wood. If we are to protect metals, then moisture resistance is paramount. Through the use of the phenolic resin in paints and varnishes we have achieved a degree of resistance to water impossible ten years ago.

Chemical resistance: In addition to the aforementioned properties of speed, durability, and water resistance, the chemical resistance of the phenolic-resin-fortified coating is outstanding. This stability involves resistance to soaps and alkalies, dilute acids and salts, oxidation, and disintegration by air, sunlight, and industrial fumes. The chemical resistance of these coatings frequently is demonstrated by immersing the films in a 5 percent solution of caustic soda. In this test rosin derivatives, fossil resins, and some synthetic resins are



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4—Three-compartment tank car for transporting wine being lined with a phenolic coating. Portable baking equipment to accelerate setting is in foreground. (Photo, courtesy Bakelite Corp.)

dissolved. The phenol-formaldehyde resin, however, enables the film to meet the modern specifications for spar varnishes or vehicles for primers, aluminum enamels, and other protective paints, requiring immersion in 5 percent caustic for 8, 24, and 48 hours.

Flexibility and its retention: The life of a resistant film is indicated by a high initial flexibility and toughness coupled with the *retention* of this property on exposure. The phenolic varnishes have high initial flexibility. This may be indicated by a kauri reduction requirement of over 140 percent for a 33-gallon length varnish. But more important to us is the retention of flexibility or life on aging. Since these new varnishes and vehicles are highly polymerized, they do not require the high oxidation as of old to form solid films. They are more nearly inert, polymerized films. Their freedom from peroxides, hydroxy acids and other unstable compounds, present in the older fossil or rosin films, gives retention of flexible life on exposure. Thus kauri reduction tests before and after exposure, or bending tests over mandrels before and after baking, show high flexibility retention.

Protection of steel in river and harbor waters: One of the engineer's greatest corrosion problems has been the protection of steel locks, dams, ships, and other construction in river waters. This has been aggravated by acidity and dissolved salts in the water and by the erosion of flowing silt and causal foreign objects. After years of testing, the U. S. Army Engineers in charge of the twenty-six locks and dams in the Mississippi River have written specifications calling for 100 percent phenol-formaldehyde resins, and for the past two years have used primers and aluminum finishing paints based on these specifications. There are 26 of these dams running from St. Paul to St. Louis, consisting of tainter and roller gates, each 30 feet or so long, and running 15 to 20 in a row. The finish must stand not only occasional, but also long period immersion in the river water in addition to the blazing sun of summer and the ice and frost of winter on the exposed areas.

Protection of the interior of steel water tanks: Another vexing problem of the paint industry and the engineer in the past has been the interior of steel water tanks. Dr. H. A. Gardner, Director of the Scientific Section of the Paint and Varnish Manufacturers Association, stated some eight years ago that if a successful coating for such tanks were developed, it would open up an annual market of over a million gallons. This problem has largely been solved through the use of the water-resistant finishing system somewhat similar to those just described. In 1934 the Pittsburgh-Des Moines Steel Company conducted a test of 196 different paints on the inside of a million gallon steel water tank. Each month the tank was emptied and two inspectors made independent reports. At the end of 18 months the test was discontinued and their Technical Report No. 3301 issued. This report stated that the only finish rating 100 percent in this test was based on a phenol-formaldehyde resin.

Marine coatings and spar varnishes: One of the first fields taking advantage of the water resistance and durability of phenolic resins was that of marine coatings and general exterior spars. Thus, most of the leading spar varnishes on the market today utilize the phenol-formaldehyde resin. The Chris-Craft motor boats and cruisers have for the past three or four years been protected and beautified with three coats of such a spar varnish. Some of the best known anti-corrosive primers and finishing coats for steel ships are based on these resins. The U. S. Navy highest grade spars and ship paints are based on a 100 percent phenol-formaldehyde specification. The Ford station wagon, outstanding as an example of the beauty and durability of a well-protected wood body, has for years been given three coats of a 100 percent phenol-formaldehyde resin varnish. The specifications of the U. S. Maritime Commission for marine "deep tank coatings" are based on similar primers and finishing paints.

Aircraft coatings: The aircraft industry brings us a combination requiring the maximum of protection that science can furnish over light alloys that are readily attacked by salt, moist air. One of the earliest and most stringent specifications embodying the use of 100 percent phenol-formaldehyde was the V-10 specification of the U. S. Navy Bureau of Aeronautics. This phenolic varnish was required not only for a clear spar and aluminum vehicle, but for the anti-corrosive primer (P-23) and the deck and pontoon enamels (M-67) as well. A viscous varnish of the same type is also specified as the seam compound required in rendering all gaskets and seams impervious to salt water and gasoline. The modern zinc yellow quick-drying primer (Specification P-27) for aircraft protection of both aluminum and magnesium alloys is based on highly dispersed phenolic resins. Likewise phenolic resins furnished the base for the protection of light alloys on the huge dirigibles. These included vehicles for the aluminum protective paint and phenolic baking coatings on the inside of aluminum condenser tubes.

Railways, street cars, and buses: A wide variety of protective paints for railways, cars, and buses, based on phenol-formaldehyde resins, is furnished by the

paint industry. Freight car paints require this tough type of protection. This is especially so in regard to refrigerator cars in which moisture condensation, and, occasionally, salt solution and fruit acids induce early corrosion. High-speed passenger and freight trains are subject to all kinds of weather and to the erosive action of cinders, smoke, and gases. The Chicago and Northwestern Railway Co. reports that because it stood up under laboratory tests, a phenolic resin finish is used on their famous "400" passenger train.

Other examples of modern paint protection: Many other types of uses where these modern synthetic resin coatings are giving exceptional performance could be cited. A passing montage would include the floors of roller skating rinks, school rooms and gymnasiums, and Hollywood dance sets, the aluminum and black guard rails lining the highways of Minnesota and the inside painting of fish hatcheries in Michigan. (Brook trout are reported to grow faster in tanks painted white with phenolic resin vehicles.) The bronze stair rails and doors of the white marble and bronze U. S. Supreme Court building are guarded against the corrosive acids in the perspiration of hands of visitors by a phenolic resin lacquer. So are the guard rails and interior stanchions of the Wayne passenger buses. Phenolic coatings protect Antioch College fume ducts and many laboratory hoods and tables; they are specified by the State of Vermont to protect maple syrup and sugar from contamination; they coat oil and gas tanks throughout the country and protect millions of dollars worth of power plant and transformer lines. They have solved the problem of protecting transformers in moist subways or under other corrosive conditions. They insure house paint against moisture blistering and cracking. They come close to us in everyday life in dozens of items from burn-proof ash trays to waterproofing our fishing rods. The furniture and cabinet industries today may procure lacquers and varnishes based on phenolic varnish resins offering new values in toughness, print-resistance, and the ability to withstand alcohol and hot water. With these resins the electrical and insulation industries are obtaining higher dielectric properties under humid conditions and longer life at higher temperatures for their wire and cable coatings.

Improved heat-hardened coatings

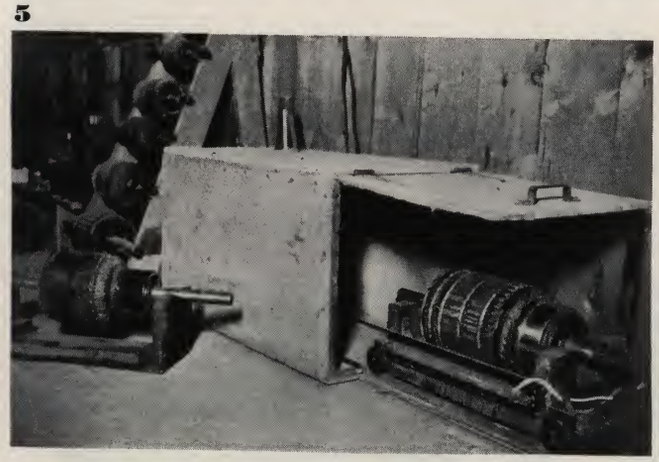
In the past few years the phenolic heat-hardenable coatings have been constantly improved. Their flexibility is greater. Required baking temperatures have been lowered by about 25 percent. Advance is continuing and shortly there will be released even newer heat-hardenable coatings which will lower the critical heat-hardening range again by some 25 percent. Laboratory materials are already under test which are converted by heat at 160 deg. F.

The recent advances in the coating of large industrial equipment such as tanks, textile processing machinery, food equipment and chemical equipment against either chemical attack or mechanical wear involve many factors, particularly proper equipment and proper technic. This art is extremely complicated and it has been developed by several specialists in the industry, notably the Lithgow Corp. and the Hastolite Chemical Corp. and Bishopric Products Co., Inc. These organizations specialize in testing various types of coating materials and evolving formulations for specific applications to bring out desired properties. They conduct accelerated tests and have accumulated within the past six years a mass of data and experience on the many problems involved in coatings and in baking technic for each application.

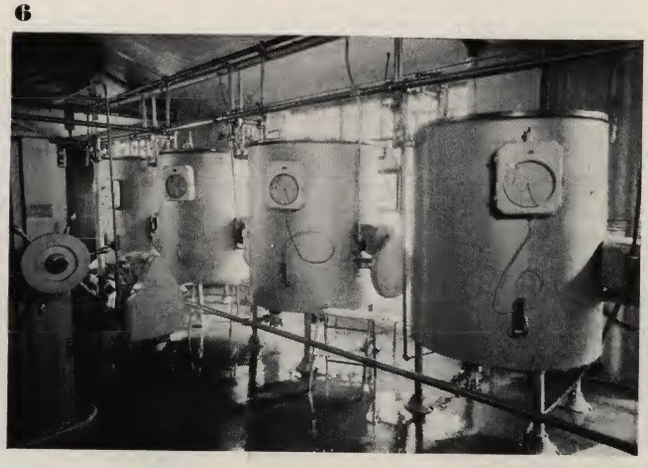
These engineers have coated some very interesting equipment in the field by way of protecting beer, wine and distillery equipment, food processing equipment, and chemical, electrical and industrial equipment. These applications have been made possible because special types of portable equipment have been designed, making it practical to coat and bake equipment already assembled in plants. This special equipment overcomes the limitations and impracticabilities of transporting fixed processing equipment to a central plant for coating and baking. Thus, huge surfaces as railway and freight cars may be thoroughly coated with little difficulty.

5—Coils impregnated with Bakelite varnish travel on T-rails through the baking oven. 6—Milk tanks at the Borden-Wieland Co. are coated with Bakelite phenolic varnish to withstand repeated sterilizing

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Vinyl resin coatings*

FUNDAMENTALLY, the only truly protective surface coating is one that is not only strong, but that is also fully resistant to the abrasion, corrosion, weathering or other conditions encountered during exposure. The structural units or molecules of such a protective coating must, therefore, have very slight chemical reactivity and relatively great size. Large resin molecules can be developed either after application, by oxidation or by heat, or during the process of manufacture of the resinous materials, prior to application. This difference in the order to events by which the large molecules are developed is the essential distinction between paints and lacquers. The vinyl ester resins fall into the latter class, their macro-molecules being developed during manufacture, before application of the resin as a surface coating. A number of resins of the vinyl ester family are available commercially, several of which can be used for surface coatings. The particular resin of the group which has been used most extensively in lacquers is a copolymer vinyl ester.

The best solvents are those that dissolve a large quantity of the resin before abnormal viscosity effects appear. According to this, ketones, as a class, give the best performance with copolymer vinyl chloride-vinyl acetate resins. Nitroparaffins and esters follow in that order. Complete viscosity studies have been made of many commercially available vinyl resin solvents having a wide range of evaporation rates. With so much latitude in evaporation rates, it is possible to formulate finishes for almost all classes of industrial applications. Because, in general, the solvent strength is reduced as the molecular weight of the solvent is increased, it has long been a problem to produce a high-boiling solvent for copolymer vinyl resins which would permit the formulation of roll-coating finishes, graining inks and stencil pastes. This problem has recently been solved by the synthesis of isophorone, a complex ketone with multiple solvating groups. Lacquers made from vinyl resin solutions in isophorone can be applied by spraying or roll coating, as they have no tendency whatsoever to string or to cobweb.

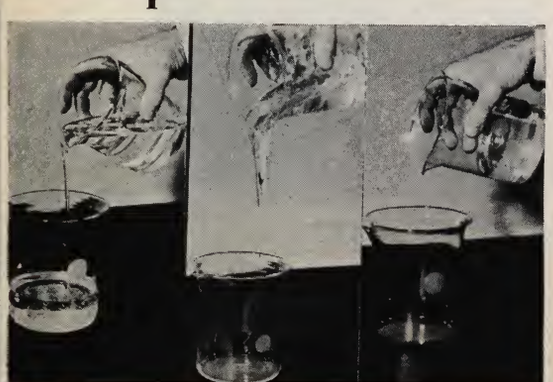
The behavior of vinyl resin coatings on various metals is worthy of mention, since this behavior is intimately related to the protective value of the coating. It is usually desirable to bake the coatings in order to improve the adhesion and to expel any residual solvent. Many surfaces are inert or "neutral" to the resin, but certain metals appear to accelerate its thermal decomposition. Zinc, tinplate and iron are the worst offenders, and vinyl finishes applied over these metal surfaces with high baking temperatures must either be stabilized or separated from the metal by means of a neutral undercoat. In comparing the effect of various baking times and temperatures on an *unstabilized* vinyl resin finish over glass, aluminum, steel and tinplate, very little darkening appears on the glass or the aluminum after 2 hr. at 350 deg. F. The surfaces of both of these are, of course, very inert, the aluminum being intimately covered by its adherent oxide film. The same finish on steel or tinplate is definitely discolored in a much shorter time at this temperature. The resin can readily be stabilized against thermal decomposition by the use of certain lead or tin compounds.

Another example of the influence of the metal surface on the character of the vinyl resin coating is found in the thickness of the film that must be applied to give a continuous coating. This subject has been extensively studied by Young and his associates, who have demonstrated that the nature of the metal surface controls the minimum thickness of vinyl resin coatings of equal protective value. An electrical method was used in which the coated panel was made one pole of a galvanic cell while the vinyl resin coating constituted the principal internal resistance. A film thickness which gave an internal resistance infinite with respect to the range of the instruments was considered to be continuous. Measurements made in this way show that the minimum coating weights for iron, aluminum, and tinplate are of

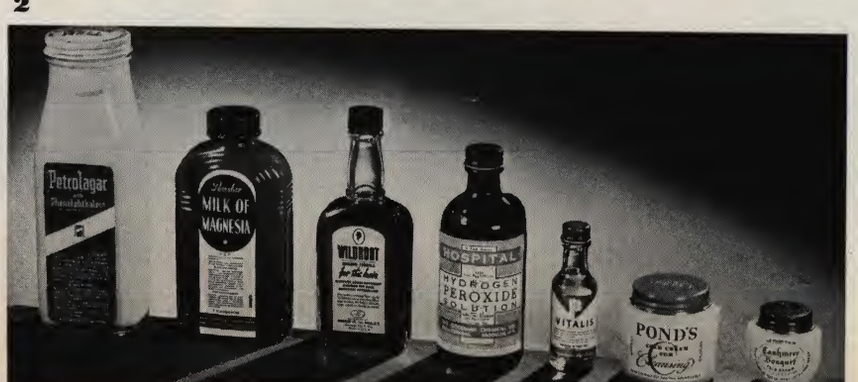
*Especially prepared for this issue by Arthur K. Doolittle, Carbide and Carbon Chemicals Corp., S. Charleston, West Virginia.

1—Vinyl resin solutions in various conditions of flow: left, normal solution, center, plastic phase, right, gel phase. 2—Drugs, pharmaceuticals and cosmetics are kept pure and fresh by vinyl copolymer liners. Thin sheets of the material are calendered on liner paper. These liners are stamped from these composited sheets. (All photos, courtesy Carbide and Carbon Chemicals Corp.)

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3—Elevator doors and frames are treated with a Vinylite copolymer resin surface coating. 4—Lithographed metal coasters, coated with vinyl resin, baked, and then formed. Their edges are crimped a full 1½ turns



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the order of 10, 6 and 3 mg. per sq. in., respectively.

With this background, it may be desirable to consider the properties of coatings made from these resins. They are ideal for use in food containers because they are odorless and tasteless; resistant to grease, alcohol and water; and immune from bacterial or enzymatic attack. The coatings are tough and flexible, and their thermoplastic character gives them heat-sealing properties. Following is an explanation of the several reasons for the unique adaptability of copolymer vinyl resin coatings as linings for beverage containers. First, the resin is tasteless. It introduces no taste to the contents and likewise absorbs or removes none. Second, it has good resistance to water at reasonable processing temperatures. This resin is practically unaffected by water at 170 deg. F. If blended with other resins, however, its resistance may be greatly impaired. Third, vinyl ester resins are also absolutely unaffected by alcohol. Extraction tests made on the dry, powdered resin with 190 proof ethanol has shown no dissolved matter after shaking for 18 hr. at room temperature. Fourth, very thin films of vinyl resin that are free from pinholes are impermeable to metal ions. Dialysis experiments have been made to study the diffusion of ferric ions through films of the order of 3 to 5 mg. of resin per sq. in. A saturated ferric chloride solution was placed on one side of the membrane and water at pH 4.2 on the other. The water was tested periodically, but no trace of iron could be detected after nearly 3 weeks. Fifth, and perhaps most important of all, the resin film is tough, flexible, and will take a deep draw without rupture. By virtue of this property of the resin, it is possible to coat sheet metal stock in the flat and to stamp the parts out afterwards. In some cases when a further draw is given certain parts in later operations, the resin withstands even this distortion without failure.

Because of these advantages, vinyl resin linings are used in many containers for products which require no hot processing. The thermoplastic nature of the resin is the only limitation on its use for certain food products. Canned vegetables, for example, are processed at 240 to 250 deg. F. and at these temperatures the resin softens enough to reduce its water resistance appreciably. Hence, in the food industry, these linings are used principally for packaging beer, some wine, grape juice and apple juice; although successful and newer applications have been made in lining metal beer barrels, pails for soft drink concentrates and tank cars used for shipping wine.

There are other applications for these vinyl resin linings in the container field, besides the packing of beverages. As an illustration, the lining of pails for cold-water paints consists of a one-coat, lead-stabilized vinyl resin coating applied directly over the bare iron. The commercial use of these pails for casein paints is evidence of the fact that this lining is alkali-resistant. Laboratory storage tests add further emphasis to this feature. In one such test, iron pails lined with a lead-stabilized vinyl resin first coat followed by a clear vinyl resin finish coat were filled with 25 percent caustic soda solution and stored from August, 1936, to June, 1939. At the end of this 34-month period, the tests were terminated with no failures apparent on any specimens.

These tests have so well proved the inertness of the vinyl resin coatings that steel drum and container manufacturers have developed completely automatic machines to handle the application of the lining material. These machines control not only the spray of the material but the rate of application, depending upon the requirements of the container. Such machinery has eliminated many difficulties formerly encountered with hand methods and has helped to obtain better accuracy and uniformity of film thickness and quality.

A field closely allied to the lining of containers is the protection of caps and closures for food, cosmetic and medicinal products. These caps are generally coated in the flat, then punched, drawn, or spun into shape. Thousands of sizes and shapes are made and they are all formed after application of the vinyl resin coating. Here again, the hard, tough and flexible vinyl resin film exhibits the ability to take an extreme draw without rupture. The general use of liquor bottle caps and cosmetic container closures finished with these resins offers further proof of their resistance to alcohol and grease.

The development of these resins as a coating material for drums and containers has been a result of continued co-operative work between the manufacturers of the resin, the lacquer and the container. This co-operation has brought about excellent results and will continue to lead the way to many new improvements, all of importance to the packer and user. With the increasing interest and wholehearted co-operation of these three, plus that of the user of the packed materials, it is believed that these coatings as drum and container liners will continue to increase in importance.

Chlorinated rubber coatings

CHLORINATED rubber was first prepared in the middle of the nineteenth century, but it was not prepared commercially until 1917. At that time, Peachey employed a method of chlorinating a 4 per cent solution of rubber in carbon tetrachloride obtaining a product with 65 percent chlorine. Since then, numerous improvements have been made in the manufacture of chlorinated rubber. The most recent is a chlorinated rubber with greatly improved original flexibility, which is retained on aging.

Chlorinated rubber is a completely saturated molecule containing approximately 67 percent chlorine. It is manufactured in five viscosities, namely, 5, 10, 20, 125, and 1000 centipoises—(all viscosities determined on the 20 percent solution in toluol at 25 deg. C. in a capillary tube viscosimeter)—and recommended for use as follows:

The 5-centipoise type for printing inks.

The 10-centipoise type for high solids chlorinated rubber lacquers and as a fortifying agent for alkyd resins and oleo-resinous varnishes.

The 20-centipoise type for general protective coating applications and also for fortifying alkyd resins and oleo-resinous varnishes.

The 125-centipoise type for concrete floor paints, paper lacquers, and adhesives.

The 1000-centipoise type for textile finishes and plastics as well as for other finishes requiring a maximum flexibility. Flexibility increases with viscosity.

Chlorinated rubber has a specific gravity of 1.64; its films are colorless, odorless, tasteless, and non-toxic. Chlorinated rubber has good mechanical and excellent electrical properties. It is stable up to 125 deg. C.; has excellent acid, alkali, mineral oil and moisture resistance; is soluble in cheap solvents; and is compatible with a large number of resins and plasticizers.

Chlorinated rubber was first used as a base material for chemical resistant maintenance-type finishes. For this application the chlorinated rubber must be modified with plasticizers, resins, pigments, and solvents. Resins and plasticizers are chosen for resistance to the corrosive conditions encountered. For this application, the chlorinated diphenyl plasticizers and the coal tar and phenolic-type resins give the best chemical resistance. In some cases where outdoor durability is also desired, some sacrifice of chemical resistance must be made. A typical chlorinated rubber chemical resistant finish for outdoor exposure would be plasticized with a combination of chlorinated diphenyl and specially treated tung oil, and would contain a soft-type phenolic resin. Chlorinated rubber chemical resistant finishes have been used successfully in chemical plants, steel plants, pulp and paper mills, the textile industry, in decorative-type finishes for equipment coming in contact with corrosive materials, and as a reinforcing material for paints, lacquers and varnishes.

Another field of application for chlorinated rubber finishes is for alkaline surfaces such as concrete, stucco, plaster and cement asbestos boards. For this application the alkali resistance of the chlorinated rubber is of great value. Satisfactory finishes for stucco walls and similar surfaces for outdoor exposure have been prepared using mixtures of chlorinated rubber and drying oils. For concrete floor paints, chlorinated rubber can be used either in lacquer-type finishes or as a fortifying agent for phenolic varnish enamels.

Chlorinated rubber has also been used as a fortifying agent for oleo-resinous varnishes for speed of dry and where improved alkali resistance is desired. It is likewise being used successfully in printing inks, especially where alkali resistance is important. Chlorinated rubber is also a good base material for adhesives.

Chlorinated rubber is also an ideal base material for moisture-vaporproof paper lacquers. In this problem it is essential to use plasticizers and resins that have a relatively high tolerance for paraffin wax such as diamyl phthalate. A high melting point paraffin wax is used since moisture-vaporproof determinations are run at 35 deg. C. Chlorinated rubber, as mentioned before, is odorless, tasteless and ton-toxic, and, therefore, can be used in connection with labels and wrapping paper for food products.

Chlorinated rubber can be used to fortify alkyd resins giving quick dry, improved alkali resistance, and excellent tint retention without detracting from the good weathering properties of the alkyd resin. The following examples will serve to indicate the large number of fields which are open to chlorinated-rubber-fortified alkyd resin enamels:

1. *Trucks and Buses*—Here chlorinated-rubber fortified-alkyds give quick dry on objects too large to be placed in ovens; finishes have excellent outdoor durability. The chemical resistance and toughness of these enamels is an important factor on trucks which come in contact with corrosive conditions.

2. *Washing Machines*—Here chlorinated rubber imparts quick dry as well as resistance to alkaline washing powders and soaps.

3. *Refinishing Automobiles*—Here chlorinated rubber gives quick dry which is especially important during the cold winter months when alkyd enamels dry slowly.

4. *Farm Machinery*—Here chlorinated rubber promotes quick dry, clean dipping and resistance to fertilizers.

SYNTHETIC FIBERS

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Nylon: monofilament and yarn—436

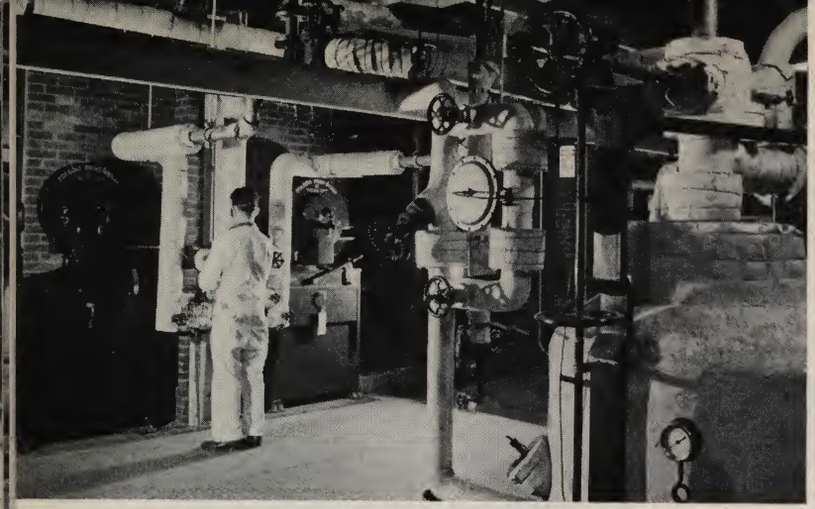
Vinyon: fiber and yarn—439

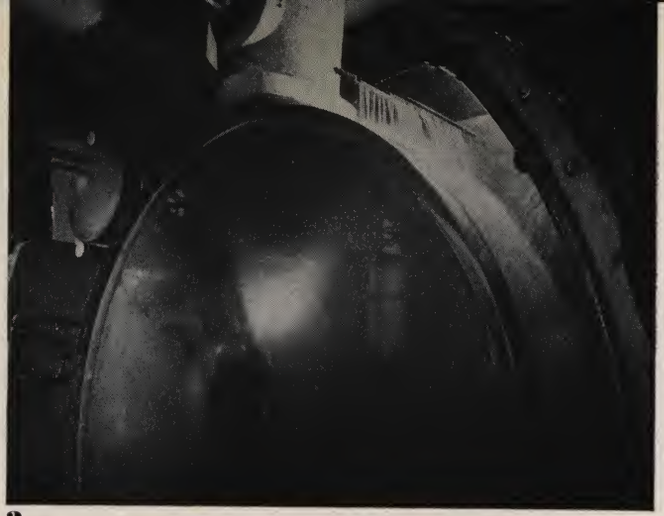
Cellulose acetate rayons—442

Protein fibers—444

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1—First stage of nylon manufacturing at the Du Pont plant. Water is evaporated from raw material. 2—Viscous polymer is extruded on this revolving wheel. Water sprayed onto material assists in solidifying it into strips which are later chopped. 3—Nylon flake poured from hoppers is ready for plasticizing in which state it is extruded into filaments. 4—Nylon yarn being sized. Wound from one spool to another it passes over a gummy substance which gives added protection

Nylon: Monofilament and yarn*

NYLON is the generic name chosen by the Du Pont company for a family of synthetic linear superpolymers—that is, compounds made up of giant molecules in the form of long chains. The particular group of superpolymers to which this name is applied are the synthetic polyamides. Chemically, the polyamides are somewhat similar to such protein materials as silk, hair and wool. Nylon is not, however, chemically identical with any known natural product, and accordingly fibers made from it cannot properly be referred to by such terms as "synthetic wool" or "synthetic silk."

Nylon may be fabricated into various forms, including bristles, sheets, and textile fibers. It follows, therefore, that the term nylon does not refer simply to textile fibers or yarns—as many seem to think—but rather to the polyamide itself, which may be fabricated into a variety of forms.

As will be indicated below in more detail, there are not only different *physical forms* of nylon, but also different *chemical species*.

Manufacture

The nylon superpolymers which make up the polyamide family can be made in several different ways. One of the simplest involves the reaction between molecules of an amino acid—that is, molecules with an amine group on one end and a carboxyl group on the other. On heating, long-chain polyamide molecules are formed, having recurring structural units.

* This article was specially prepared for this issue by Jas. K. Hunt, E. I. du Pont de Nemours & Co.

Intermediates used in the manufacture of one type of nylon are derivable from such domestic raw materials as coal, air and water. Other types, however, may demand intermediates based on other raw materials, including vegetable oils.

Since there are dozens of different intermediates which may be used in making synthetic polyamides—including dibasic acids, diamines and amino-acids—it follows that many different chemical types of nylon are possible. Assuming only 5 different dibasic acids and 5 different diamines, it would be possible to make 25 different nylons. Actually, by interpolymerization of various dibasic acids, amino-acids, and diamines, thousands of different nylons are possible. Also, two or more different nylon polymers may be blended to give compositions different from the parent nylons. It should be apparent, therefore, that an almost unlimited number of nylons are possible, each with its characteristic physical properties. Some, for example, might be quite flexible, while others would be stiff or rigid.

Properties

1. *Nylon is crystalline.* The various polyamides which make up the nylon family are crystalline in structure, as indicated by the characteristic X-ray diffraction pattern.

2. *Cold drawing of nylon.* An interesting and significant physical property of nylon is that it can be cold drawn. This is an unusual property for crystalline organic materials, which are normally brittle when cold. A filament of nylon which has been made under low tension can, if subjected to further tension, be drawn to from four to seven times its original length, depending upon the particular polyamide being used.

The long chain-like molecules which make up the undrawn fiber have a haphazard arrangement like the straws in a haystack, but on drawing this fiber to several times its original length, the long-chain molecules become *oriented*—that is they take on an orderly, parallel arrangement. Nylon bristles, yarn, and thread are shipped from the plant properly drawn.

3. *Elasticity and tensile strength.* Cold-drawn nylon fibers possess not only a high degree of true elasticity, but also great tensile strength. As a matter of fact, a properly oriented nylon filament has a higher combined elasticity-tensile strength than that of any commonly used textile fiber, and it is chiefly this property of drawn nylon which causes the yarn to lend itself so well to the manufacture of fine hosiery.

4. *Toughness.* Drawn nylon appears to possess in high degree all of the different physical properties embodied in the quality known as *toughness*. It is because of this property, among others, that oriented nylon bristles are well suited for use in toilet brushes and certain types of industrial brushes.

5. *Resistance to heat.* In common with other crystalline materials, nylon has a fairly sharp melting point. As might be anticipated, the temperature at which nylon becomes liquid depends upon the chemical composition of the particular nylon. While nylons have been made which melt at quite low temperatures, the melting point of others may run as high as 600 deg. F., or even higher. The melting point of one type which now appears particularly suitable for textile purposes is about 480 deg. F., which is above the temperature normally used in ironing fine fabrics.

6. *Flammability.* Fabrics made from nylon yarn do not blaze when brought in contact with a flame. The nylon simply melts, and although the molten nylon is ultimately consumed if kept in the hot flame, the fabric

5—Textile printing machine equipped with a nylon bristled furnisher brush. The dye is picked up from shallow vat and conveyed to engraved roll. 6–7—Nylon bristles for bottle washing, dental cleaning, hair and tooth and rotary-type brushes

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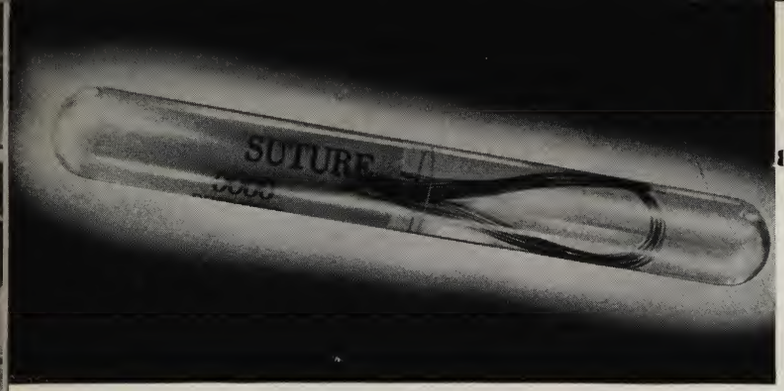


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8—Nylon surgical sutures are infection-free, non-irritating and have no rough or frayed sides. 9—A boon to fishermen, nylon leaders need not be moistened before using, are elastic, non-brittle and will not split

itself does not blaze and propagate flames. In the fire protection engineers' parlance, nylon fabrics are "practically non-flammable."

7. *Water resistance.* While nylon fabrics of the type now in use are readily wetted by water, the fibers absorb much less water than do other commonly used textile fibers, with the result that a pair of nylon stockings, for example, will dry extremely rapidly. By the same token nylon bristles do not become soft and flabby on contact with water. In addition, nylon fibers and bristles are substantially as strong when wet as when dry.

8. *Resistance to dry-cleaning fluids.* Nylon of the type used in textiles is not injured in the least by dry-cleaning fluids or other liquids commonly used about the home.

9. *High temperature "setting."* Hot water or saturated steam imparts a substantially permanent *set* to nylon yarn and fabrics. Advantage is taken of this property in the *pre-boarding* of nylon hosiery, with the result that such hosiery, after repeated wear and washing, is substantially as well formed as when in the original package.

10. *Influence of light.* While all organic textile materials are injured more or less by long exposure to light, nylon fabrics appear to be at least equally as resistant to either indoor or outdoor light as are corresponding silk fabrics. Nylon fabrics undergo no appreciable deterioration in the absence of light and may accordingly be stored for long periods of time without injury.

11. *Moth and mildew resistance.* Nylon fabrics are absolutely proof against attack by moths, or by fungi such as those responsible for mildew.

12. *Optical properties.* As ordinarily made, nylon in the massive state is opaque, but sheets no thicker than about $1/4$ in. are somewhat translucent. By means of a special process, however, nylon films may be made quite transparent. Of interest to the physicist is the fact that drawn nylon is highly doubly refractive.

13. *Electrical properties.* Certain of the nylons have very good insulating properties. One type has a volume resistivity of 4 by 10^{14} ohms per centimeter (at 18 percent relative humidity). When saturated with water, the electrical resistance of this type is reduced to about 5 by 10^{9} ohms per centimeter.

Because of its good insulating properties, but more particularly because of its extremely high abrasion resistance, certain of the nylons appear quite promising as insulation for the wires in various types of electrical machinery and apparatus. For this purpose the wire is encased in a continuous film of nylon, applied from molten nylon polymer or from a solution or emulsion of nylon.

Present status

Late in 1939, the first spinning machine for nylon yarn was started at Seaford, Delaware. Currently the capacity of this plant is about 4,000,000 pounds of nylon yarn per year, most of which is furnished to hosiery mills to be knitted into stockings. In addition, nylon flake for monofilament purposes and other possible applications is being produced at Seaford. Nylon monofilament (single strands for bristles, fishing leaders, surgical sutures, etc.) is fabricated at Arlington, N. J., and as in the case of nylon yarn is furnished to other manufacturers who make it into finished products.

Forms available

Yarn, bright or delustered; monofilament.

From these elementary forms, manufacturers fabricate a variety of products, as indicated below.

Typical applications

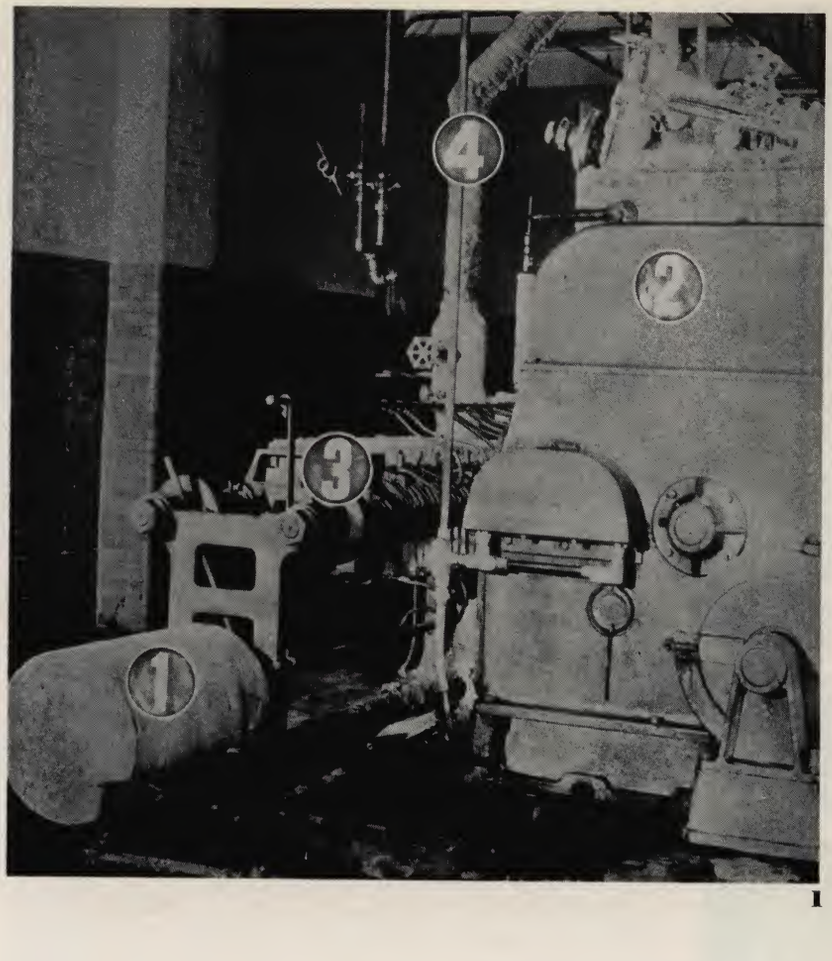
1. *For nylon yarn.* Hosiery and other knitted fabrics, woven fabrics, fishing lines, surgical sutures, bead cord, sewing thread, shoe laces.

2. *For nylon monofilament.* Bristles for toilet brushes and industrial brushes, surgical sutures, fishing leaders, strings for tennis rackets and musical instruments.

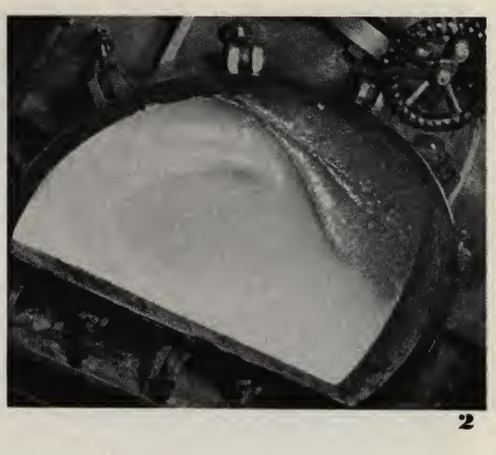
3. *For nylon flake.* Electrical insulation.

Properties

Extreme toughness, low water absorption, and when drawn, high tensile strength and elasticity.



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1—Photograph at left shows manufacture of Vinyon—(1) Vinylite resin tank container (2) mixer (3) filter press (4) insulating piping indicating importance of close temperature control. 2—Overhead view of mixer showing the material in second stage of process. (Photos, courtesy American Viscose Corporation)

Vinyon: fiber and yarn*

THE basic material of *Vinyon*** synthetic fiber is a special grade of unplasticized vinyl resin, the copolymer of vinyl chloride and vinyl acetate. There are six major steps in the production of these fibers and yarns. The procedure is as follows:

First: The vinyl resin, from which Vinyon fibers are made, is delivered to the rayon plant in the form of a white powder of very fine consistency, rather like flour.

Second: The resin is emptied into agitator mixers and dissolved in acetone. It is then filtered and stored in tanks. In the dissolving process it is kept at a temperature of 50 degrees centigrade. (When cold it has a gelatine-like consistency.) At the time of being stored in the tanks, the heated solution is clear and has the general appearance of a heavy syrup. In this state it is known as "dope."

Third: From the tanks the dope goes to the spinning machine which is standard acetate rayon spinning equipment. The process here is substantially the same as that used in making acetate rayon, except that higher air pressures and temperatures are used. Heating is of major importance at this point. The temperature required for spinning dope is double that required for acetate rayon. As with acetate, the dope is converted to a textile yarn at the spinning machine.

Fourth: The yarns are stretched to increase tensile strength and reduce extensibilities. During this operation the factor of elevated and strictly controlled temperatures is important.

Fifth: The yarns are oiled and twisted.

Sixth: Yarns are redrawn on cones and spools and then are ready for shipping.

Properties of the yarn

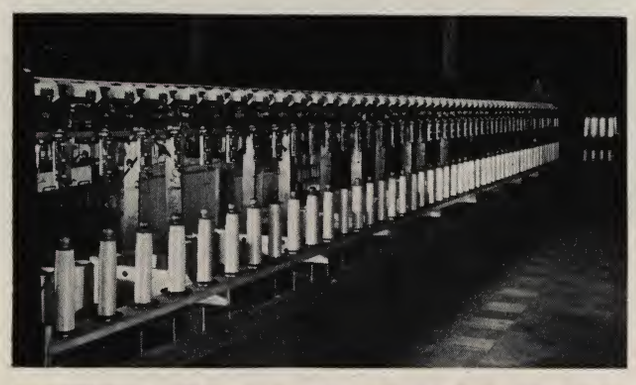
Tensile strength. The tenacity may be controlled at will within the range of 1.0 to 4.0 grams per denier and the elongation within the range of 120 percent to

* This section was prepared with the aid of R. K. Kennedy, Carbon & Carbon Chemical Corp. and John Black, for American Viscose Corp.

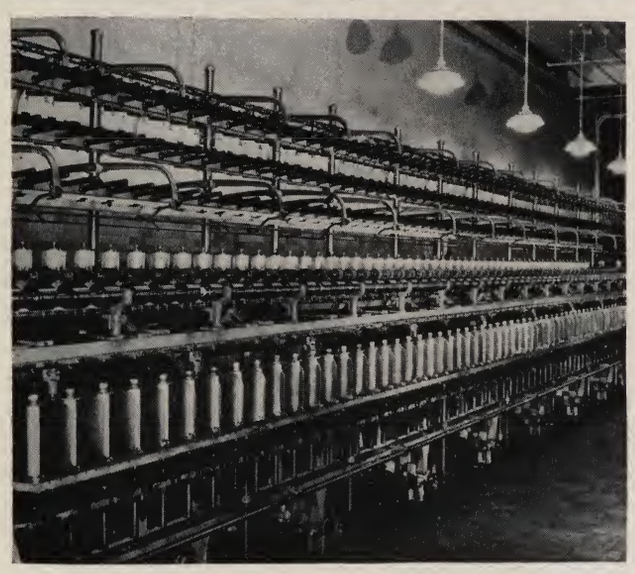
** Registered trade mark, Carbide Carbon & Chemicals Corp.



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18 percent, an increase in tenacity having a concomitant effect of reduction in elongation.

Unlike any other synthetic fibre, the tensile strengths of the yarns are of the same magnitude in both the wet and dry states.

Water resistance. The yarn is definitely and permanently water resistant. Surface wetting may be accomplished by use of wetting agents.

Flammability. The yarn will not support combustion.

Resistance to heat. The yarn is definitely thermoplastic. A temperature in excess of 65 deg. C. will cause shrinkage of the yarn, the shrinkage being definite for the temperature to which it may be subjected; for example, at 75 deg. C. a shrinkage of about 12 percent results. At 80 deg. C., the individual filaments of the thread will shrink very materially and will tend to adhere to each other. At about 135 deg. to 140 deg. C. definite tackiness in the thread will develop.

Certain industries are taking advantage of these properties by using the fiber as a thermoplastic binding agent and to produce shrunk-fit tubings or sheets. Concurrent with this shrinkage, the fabric takes on certain unique characteristics for specialized applications.

Chemical resistance. Vinyon synthetic textile yarns and fabrics made therefrom are exceptionally resistant to mineral acids and alkalies. The fabric is not attacked at room temperature, for example, by 70 percent nitric acid, by aqua regia, by hydrochloric or hydrofluoric acids of maximum concentration, by 30 percent sodium hydroxide or 28 percent ammonium hydroxide. It is likewise resistant to salt solutions of all types, to cuproammonium solutions, etc. It is dissolved by ketones and is softened or partly dissolved by esters, certain halogenated hydrocarbons, ethers, certain amines, and by

6



3—An important step in Vinyon manufacture is the stretching operation. These are the machines which perform this operation. 4—Photograph showing Vinyon being wound on spools or spindles. This step is one of the last before the yarn is shipped to weavers or converters. 5—The filaments as they are being oiled and twisted. This is standard rayon equipment. 6—Rapid drying and water resistance are characteristics of this bathing suit made from Vinyon



7—To replace wool, formerly essential for making felt, 15 to 20 percent of Vinyon has been introduced with interesting potential use in the field of liquid and air filtration

7

lower aromatic hydrocarbons. It is unaffected by alcohols, glycols and aliphatic hydrocarbons.

Bacteria and fungi resistance. Vinyon yarn and its fabrics are not attacked by bacteria and fungi and will not support such growths.

Electrical properties. The yarn is definitely non-conducting as evidenced by the tendency of the material to develop and to retain static charge.

Stability. A satisfactory stability to sunlight has been demonstrated in company tests.

Dyeing. A procedure for dyeing over a wide range of colors has been developed.

Delusterization. Delusterization, to any extent, may be accomplished by incorporation of pigment in the spinning dope. A mild delusterization may be readily realized by a new process which does not impair the tensile properties nor has the yarn any abrasive action.

Controllable shrinkage. Vinyon yarn when untensioned and subjected to elevated temperatures shows a definite crimpage or shrinkage—a contraction in length quite consistent for each temperature stage. The shrinkage is accompanied by a slight reduction in tenacity of the yarn and an increase in elongation.

General textile processing. The material readily lends itself to the ordinary throwing operations. Preferably, according to the manufacturer, the yarn should be run under high relative humidity conditions.

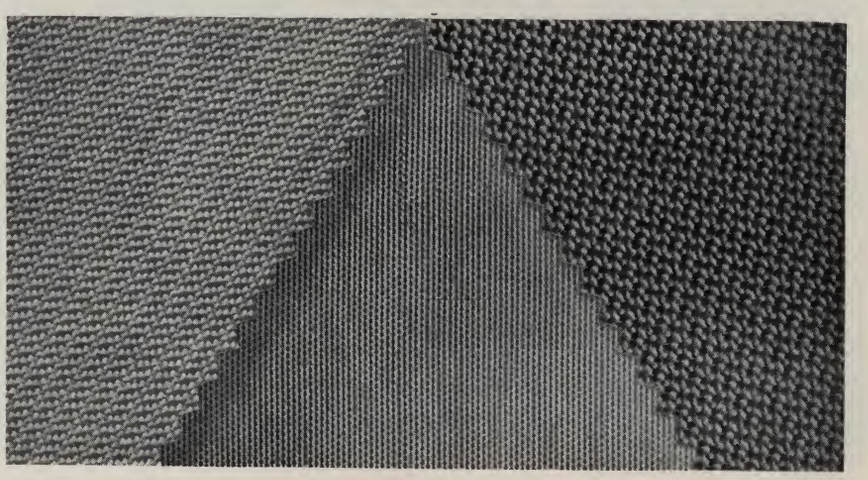
The knitting properties of the yarn are exceptionally good. In tests conducted on hosiery, ribbing and circular knitting machines, the indications were that one grade of the yarn is more adaptable to this operation than are the commercial rayons as evidenced by ease of securing much tighter stitch without thread rupture.

The yarn also serves well as filling and as warp supply in weaving. Operations under conditions of high relative humidity are desirable to preclude static development. In this, as in all operations, Vinyon yarns may be run while surface-wetted since there is no strength impairment under any conditions of wetting.

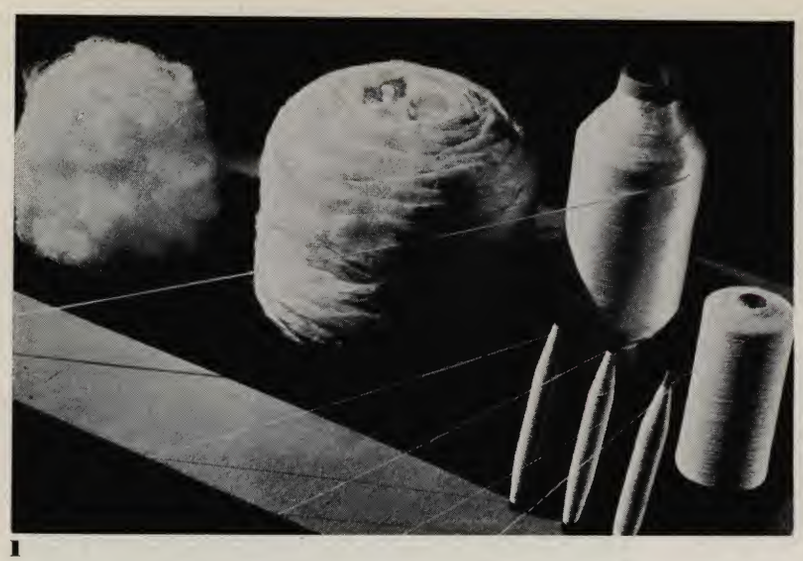
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8—In addition to its many developed and potential applications, Vinyon has promising opportunities in the apparel field as the bathing trunks indicate. 9—The chemical and physical properties of Vinyon make it a valuable material for filter fabrics as this group of varied textures indicates. (All photos on this page, courtesy *Textile World*)



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1—Crimped cellulose acetate staple fiber starts out as a continuous filament. In producing certain yarns it is chopped to lengths from 3/4 in. to 9 in. and is then spun by the same system as silk or wool. 2—Continuous filament acetate rayon as it comes from the spinneret is uniformly smooth and unbroken. It is wound on spools, cones, cops and in skeins. In these forms it is used by the textile mills. Dull yarn is made by adding a small amount of white pigment to the cellulose acetate solution before spinning. (Photos, courtesy A. M. Tenney Associates)

Cellulose acetate rayons*

CELLULOSE acetate rayons are composed of acetone-soluble cellulose acetate. The production of cellulose acetate on a laboratory scale was first accomplished in 1865, but did not attain any commercial importance until about the beginning of the twentieth century. Efforts to transform it into textile filaments or fibers were made by a number of experimenters, including Cross and Bevan, Bronnert, and Mork, Little and Walker. This experimental period which began just before 1900 culminated in the successful commercial production of acetate rayon filaments by the Dreyfus brothers in England shortly after the close of the World War. Since then, acetate rayon has rapidly increased in importance, particularly in the United States, whose production for 1939 was 100,000,000 lbs., or more than 30 percent of the entire rayon production. It is made by five companies.

Chemistry of formation

The chemistry of the formation of cellulose acetate for rayon is essentially the same as that employed for making cellulose acetates for other purposes, and involves the general principle of reacting purified cotton linters with acetic anhydride (dissolved in glacial acetic acid) in the presence of a catalyzer with subsequent hydrolysis of the highly acetylated product until the acetyl content is reduced to an amount approximating the diacetate. The calculated acetyl content of cellulose diacetate is 35 percent. The range of acetyl content which confers the desirable acetone solubility is approximately 36 to 41 percent acetyl. Within the acetone-soluble range an increase in acetyl content lowers the viscosity of the spinning solution produced therefrom, but the viscosity for a given acetyl content is subject to considerable control by other factors in the manufacturing process. The acetyl content affects the properties of the filaments and yarns: a higher acetyl producing a harder, more wiry filament and a lower acetyl a softer, limper one. The melting point increases somewhat with increasing acetyl. Each acetate rayon manufacturer has worked out a composition best suited to his purposes and each attains amazing uniformity in this respect by careful blending and control at every stage.

The transformation of the flake cellulose acetate into filaments and fibers is essentially a physical process, accomplished by dissolving the cellulose acetate in acetone, filtering and blending the highly viscous spinning solution and then forcing it downward through fine holes into a rising current of warm air which evaporates the acetone, thus coagulating the cellulose acetate in the form of continuous filaments which pass out of the

* This article was especially prepared for this issue by Harold DeWitt Smith, A. M. Tenney Associates, Inc.

bottom of the spinning chamber and are wound up on a bobbin or spool. No further chemical treatments or wet treatments are necessary. The yarn is subsequently given the desired number of turns, twisted and wound onto the shipping package.

General characteristics

The physical properties of the acetate rayons are controllable within rather wide limits. Lustrous filaments are composed of pure cellulose acetate; dull filaments are made by the addition of a small amount of titanium oxide pigments to the spinning solution; black filaments by the similar incorporation of a black coloring material. Other colors are also possible technically, but have not proved commercially practicable because of the problem of changing color fashions and consequent inventory problems. The size of the filaments and their strength and elongation, and the shape of the cross section, are controllable within limits by the spinning conditions. Filaments as fine as silk and filaments or fibers as coarse as carpet wool are available commercially, with a variety of sizes in between.

The distinctive properties which characterize the acetate rayons include:

(1) Suppleness and hand—acetate filaments have a softness to the touch and a suppleness which results in exceptional draping qualities and a pleasant feeling against the skin.

(2) Natural crease resistance—the nature of cellulose acetate results in a degree of elasticity or resilience in the filaments which gives acetate fabrics a marked resistance to wrinkling and creasing without the assistance of crease-resistant finishes of any kind.

(3) Low moisture absorption—acetate rayon is markedly less hygroscopic than wool or viscose rayon or silk, and slightly less than cotton. This insensitivity to moisture is accompanied by much less swelling of the fiber substance which has a number of favorable aspects, including the resistance of the fiber to absorbing stains and to sagging or stretching because of the fact that there is relatively little swelling of the fibers wet by water. Wet acetate rayon fabrics dry quickly.

(4) The clarity and whiteness of cellulose acetate results in filaments which have an inherent whiteness stable to washing and to light and which, therefore, require no bleaching.

(5) Cellulose acetate rayons are dyed with dyes which, in general, do not affect other rayons or natural fibers. This permits interesting multi-color or cross-dyeing effects when acetate is used with one or more fibers in the same fabric; solid shades may also be obtained by using a suitable dye for each of the fibers present.

Recent developments

The consumption of regular commercial types of acetate rayon, including continuous filament yarn and staple fiber in both bright and dull luster, has continuously expanded as a result of a steady improvement in physical properties and an increasing range of fineness in the deniers of the individual filaments as well as in the size of the yarn. Special types which have recently appeared include a crimped acetate rayon staple fiber with wool-like characteristics; Forte yarns of exceptional high strength and fine filaments; and a bulky, fluffy type of yarn made by incorporating myriads of tiny air or gas bubbles within the filaments.

3—This bridal ensemble is made from cloth woven from Eastman acetate rayon. It exemplifies the soft loveliness of the material. 4—Teca cloth of cellulose acetate base was used for creating this cool beach costume. 5—Travel ensembles for the entire family woven entirely with Celanese yarn, staple fibre and wool. (Photo, courtesy Celanese Corp.)

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Protein fibers*

Casein

The Bureau of Dairy Industry and other organizations have done considerable work on the development of textile fibers from casein which resemble the Italian "Lanital." It is reported that a concern is producing casein fiber commercially at the rate of 10,000 lbs. per week, and using it in a mixture with wool in 25/75 proportions to produce felt.

Essentially, the production of fibers from dispersible protein, such as casein, consists in extruding a heavy dispersion of the protein through small holes into an acid bath, the dispersion having been hydrolyzed to the proper degree in strong caustic, possibly to the breaking of the cross linkages in the side chains, in order that the protein molecules may have the fibrous structure of extended polypeptide chains. The acid immediately coagulates the protein fiber which is then wound into skeins and immersed in formaldehyde solution to harden. The resulting fiber has many of the properties of natural wool, but lacks its strength, especially its wet strength. In consequence, these artificial protein fibers are never used alone, but always in mixture with natural wool, the wool always at least equalling the amount of synthetic protein fiber and usually in considerable excess.

Mention may be made also of work that has been done in producing a fiber from peanut protein, and there are claims that a fiber from fish protein is being produced commercially in Germany.

For protein fiber to become successfully established in the industrial picture as a volume commodity, much further improvement will be necessary. As the results from research laboratories become available to chemical engineers, these improvements may be expected.

Soybean

The development of a soybean protein fiber is a natural outgrowth of the desire to produce a wool-like fiber from a vegetable protein available in large quantities at low cost. An average production of 25 bushels of soybeans to the acre contains about 600 lbs. of protein. Of this quantity 500 lbs. or more may be converted in the course of processing into soybean protein fiber.

In brief the process of producing the fiber is accomplished in five steps:

1. Extracting the oil from flaked beans.
2. Preparing the protein from oil-free meal.
3. Dissolving the protein to give a viscous, stringy solution.
4. Spinning the fiber.
5. After-treating the fiber.

General characteristics.—The finished fiber is white to light tan in color with medium luster, it has a very warm soft feel, natural crimp and a high degree of resilience.

The tensile strength of soybean protein fiber is about 80 percent as compared to wool while its dry elongation of 40 percent and wet elongation of 60 percent are much higher. The tensile at the break is approximately the same dry and wet; however, the yield point is lower on the wet.

The specific gravity of soybean fiber is 1.31 measured in water. The fiber is nearly circular and has very little pigmentation. Water does not wet soybean protein fiber as readily as it does casein fiber and wool. Preliminary experiments indicate that soybean protein fiber is very resistant to the action of mold as compared to casein fiber.

Forms available.—Fiber sizes range from $1\frac{1}{2}$ denier to 5 denier in staple lengths of $1\frac{1}{2}$ inches to 6 inches. It can be produced in natural color or spun dyed with or without a fixed, highly permanent crimp.

Utility.—Recent refinements in processing have produced a soybean protein fiber highly resistant to carbonizing and to boiling in dilute acid and alkali.

The fiber has been handled on conventional cotton and worsted equipment and shows great promise as a new, distinctly different fiber eminently suited in wool blends for use in suitings and upholstery fabrics. The availability of the fiber in fine deniers with a fine crimp and great resilience indicates its usefulness with cotton and spun rayon in the development of many new materials. Still another development that is being investigated is the use of soybean fiber with wool in felt manufacture.

* This article was prepared from material submitted by George H. Brother, U. S. Regional Laboratory, and R. A. Boyer, Ford Motor Company.

1—Soybeans are a typical source of protein fiber. Raw soybean protein, a bottled sample of protein spinning solution and a skein of soybean fiber and some carded fiber. 2—Protein fiber in storage after carding. 3—Laboratory production of protein fiber which incorporates the essential steps of the process. (All photos, courtesy Ford Motor Co.)

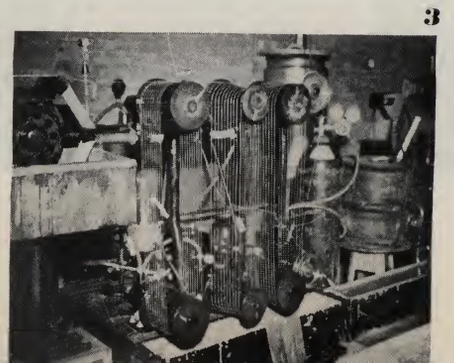
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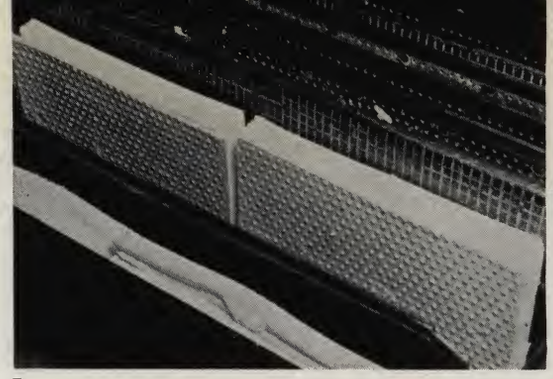


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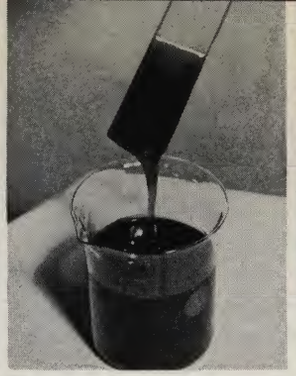


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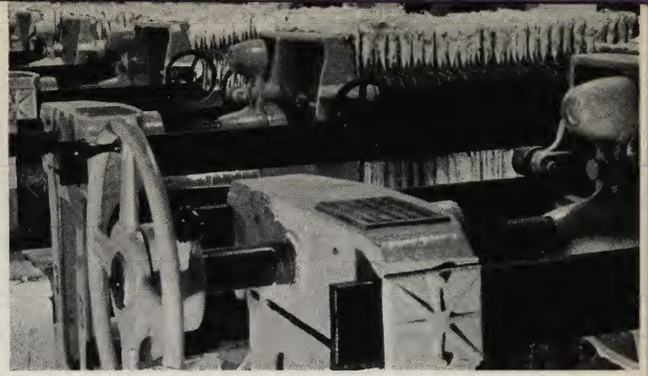




1



2



3

1—Cellulose pulp as it appears after being steeped in caustic soda. The liquid has been pressed out and run off. 2—Viscose solution, ready for spinning, is the color and consistency of honey. 3—The viscose is pumped through filter presses to remove foreign bodies and any granular substance which might be present. (Photos, courtesy American Viscose Corp.)

Viscose rayon

FUNDAMENTALLY, the process of manufacturing viscose rayon is fairly simple. One should bear in mind that the idea is to reduce cellulose, a solid, to a liquid, spin the liquid into filaments, which are regenerated into cellulose, once again a solid.

The six main steps in the manufacture of viscose rayon yarn are as follows:

1—Making and purifying cotton or wood pulp for cellulose base.
2—Caustic soda treatment of the cellulose base, forming alkali cellulose.
3—Treatment of alkali cellulose with carbon disulphide, forming cellulose xanthate.
4—Dissolving the cellulose xanthate in weak caustic soda to form cellulose solution, or viscose.
5—Spinning viscose into yarn.
6—Finishing or purification of the yarn.

1. Cellulose preparation

For many years only wood pulp was used as a base in the viscose process, and the three other processes used only cotton. Then cotton was introduced into viscose, and either cotton or wood or both together were used. Now the other processes are showing interest in wood pulp. It must be remembered that a pure cellulose that can be reduced to a solution is desired and that the nature of the fiber in wood or cotton bears no relation to the finished rayon yarn fiber.

In the pulp mill, before the material reaches the spinning plants, the raw stock in the form of spruce wood or cotton is cooked by the aid of chemicals and live steam in a large boiler called a digester. This cooking removes resin, gums and foreign matter from the natural cellulose. After leaving the digester, the mass is thoroughly washed to free it from all chemicals and then bleached to bring it to a proper degree of whiteness. The cellulose now consists of minute short fibers, which are run through a series of rolls to squeeze out the water. This compresses the fibers into sheets of about the thickness and consistency of blotting paper.

2. Alkali cellulose

In the rayon plant, the first step is to mercerize the pulp. The large sheets of cellulose from the pulp mill are cut into sheets approximately 12 in. by 18 in. and carefully mixed as to different lots. They are placed on edge in long vats and are steeped for about two hours in a solution of caustic soda. This steeping process extracts certain impurities left in the pulp during its manufacturing, and at the same time forms alkali cellulose. The excess liquor is then drained from the pulp and the last traces are forced out by compressing the sheets with a hydraulic ram.

The sheets are lifted from the vats by workers wearing rubber gloves as protection against the caustic. They are dropped into a machine that contains revolving blades which tear the pulp and break it into fine crumb. The crumb is dumped into a truck and thence into a number of pans resembling large baking pans. These containers of crumb go into the aging cellar for about 48 hours. Chemical action is in constant progress after the introduction of caustic soda, and the time and temperature of the aging is carefully controlled to insure a uniform product.

3. Cellulose xanthate

The crumb, now alkali cellulose, is placed in a revolving churn and a measured amount of liquid carbon disulphide is added. The mixture is slowly revolved for a few hours, and cellulose xanthate is formed. This is a light-orange substance still in crumb form, but it is now plastic and can readily be dissolved in water.

4. Viscose

The cellulose xanthate is dumped into a mixer containing a weak solution of caustic soda. Rapidly re-

volving blades beat and thoroughly mix the substance until it becomes one uniform mass. This mixing is the final process in converting the cellulose to the liquid honey-like form called "viscose." The word is derived from "viscous," meaning adhesive and glutinous.

The solution, after mixing, must be aged by standing in large tanks at an even temperature. Before leaving the aging cellars for the spinning rooms, it must be very carefully filtered to remove all dirt and foreign matter accumulated during the manufacture up to this point, for a very minute particle could plug a filament hole in the spinning operation. A vacuum is put on the tank to remove all air bubbles also, as a bubble could cause a break in spinning.

5. Spinning

The mechanical part of the spinning operation, simply stated, consists of forcing the viscose through a nozzle or spinneret about the size of a dime, containing a number of fine holes. The viscose is conveyed in pipes from the aging cellar to the spinning room, first being fed to a pump which forces an exact amount per minute through a filter, and then through the spinneret. The spinneret, on the end of a feed pipe, is immersed in an acid bath. The viscose, on leaving the spinneret, is immediately hardened or reverted by the acid and drawn away from the spinneret before the filaments have time to merge or run together again. Each hole forms a filament and the combined filaments from one spinneret form a thread of yarn. The holes in the spinneret through which the liquid is forced are from two to five thousandths of an inch in diameter. These holes are practically invisible to the naked eye unless held before a strong light. The spinneret is usually made of platinum to permit the accurate drilling of such fine holes and to resist wear.

In *spool spinning* the filaments are drawn off by a spool revolving at a certain speed and are wound onto the spool without twist. After the spinning operation, and while it is still on the spool, the yarn is given a thorough washing to remove all traces of chemicals from the spinning bath, and is then dried. The twisting operation consists of drawing the filaments from the spool and, by the aid of a rapidly revolving spindle, putting in the desired twist while winding onto another spool. The yarn is then reeled from the second spool into skein form, or wound onto cones.

In *box spinning* the separate twisting operation is eliminated. The filaments, on leaving the spinneret, pass over a revolving wheel and from there through a glass funnel into a rapidly revolving pot or cylinder called a spinning box. The funnel moves slowly up and down the center of the spinning box, and the yarn emerging from the bottom of the funnel is by centrifugal force laid in a coil against the side of the cylinder. The filaments are still parallel until they leave the bottom of the funnel, but as the rim speed of the cylinder is greater than the speed at which the filaments are entering, they are twisted together before they are laid on the side wall of the cylinder. When sufficient yarn has been spun into the box, the spindle is stopped and the yarn in the shape of a hollow cylinder about one inch thick is removed.

The procedure outlined so far will produce a bright rayon yarn. If a semi-dull or dull yarn is required, a dulling agent is added to the viscose solution which gives the desired appearance to the finished yarn. There are two general types of dulling agents which produce their effect in quite different ways. One is in the nature of an oil which, when introduced into the viscose, forms minute bubbles that mark the surface of the filaments after spinning and break up the otherwise smooth reflection of light. The other is a pigment or material ingredient of microscopic fineness which when introduced into the viscose, becomes a part of the filaments after spinning and causes them to be opaque, dull and lusterless. Yarns made by this process are sometimes called "pigment yarns," and even the fabrics made from them are sometimes spoken of as "pigment fabrics."

6. Bleaching and washing

The package of yarn is now ready for purification. In the so-called cake-washing process the purification of the yarn is accomplished while the cake is still in the original form; otherwise the cake is reeled into skeins, the standard size of which is about 44 inches in circumference, and washed in that form.

All finishing treatment, washing and bleaching, are done with the yarn in skein form. The skeins are placed on rods and run beneath a series of showers. The sulphur and other chemicals are thoroughly washed out. The yarn is bleached to a pure white and washed again. It is then dried and conditioned to the standard moisture content and is a finished product. The cellulose is back in the original pure state, but instead of being in the form of pulp fiber it is in the form of continuous, tenacious yarn.

4



5



4—Viscose Rayon as it comes from the spinning box. 5—Washing and bleaching is done with the yarn in skein form. The skeins are placed on rods and run beneath a series of showers. Sulphur and other chemicals are thoroughly washed out

DIASTICIZERS CHART 1941

PLASTICIZERS CHART - 1941

NAME	FORMULAS Empirical and Structural	Molecular Weight	Specific Gravity	Refractive Index	Vapor Pressure	Boiling Range	Melting Point	Flash Point (Cleveland open cup)	Solubility in Water	Common or Trade names	Manufacturers (See list at bottom of page for key to numbers)
ABIETIC ACID DERIVATIVES					mm. Hg.	°C	°C	°C	% by wt.		
Hydrogenated methyl abietate	$C_{21}H_{36}O_2$ —	320	1.025–1.035	1.515–1.521 21@20°	<0.01 @ 25°	365–370	—	185 180-	Insoluble	Hercolyn	9
ACETANILIDE DERIVATIVES											
Acetoacetanilide	$C_{10}H_{11}O_2N$ $CH_3COCH_2CONHC_6H_5$	177	—	—	—	—	85	—	Slight	—	4, 19
Acetoacet-*o*-chloranilide	$C_{10}H_{10}O_2NCl$ $CH_3COCH_2CONHC_6H_4Cl$	212	—	—	0.1@20°	—	107	None	—	Chloracetoacetanilide	4, 19
Acetoacet-2,5-dichloranilide	$C_{10}H_9O_2NCl_2$ $CH_3COCH_2CONHC_6H_3Cl_2$	246	—	—	<0.1@20°	—	96	None	—	Dichloracetoacetanilide	4
ACETONE DERIVATIVES											
Benzoyl acetone	$C_{10}H_{10}O_2$ $C_6H_5COCH_2COCH_3$	162	1.090@15°	1.5678@ 25°	<0.1@20°	261–262	58	—	5.0	—	4
ACONITIC ACID DERIVATIVES											
Triethyl aconitate	$C_{12}H_{18}O_6$ $C_2H_5OCOCH{=}C(COOC_2H_5)CH_2COOC_2H_5$	258	1.096@25°	1.4517@ 26°	—	154–156@ 5 mm.	—	—	0.18	—	14
Tri-*n*-butyl aconitate	$C_{18}H_{30}O_6$ $C_4H_9OCOCH{=}C(COOC_4H_9)CH_2COOC_4H_9$	342	1.018@20°	1.4532@ 26°	—	169–171@ 5 mm.	—	—	Insoluble	—	14
ADIPIC ACID DERIVATIVES											
Diethyl adipate	$C_{10}H_{18}O_4$ $C_2H_5OCO(CH_2)_4COO_2CH_5$	202	1.002@25°	1.426@ 25°	—	245	−14	—	0.060	—	8
Dimethoxyethyl adipate	$C_{12}H_{22}O_6$ $CH_3OC_2H_4OCO(CH_2)_4COOC_2H_4OCH_3$	262	1.075@25°	1.439@ 25°	—	—	−16	—	1.420	—	8
Diethoxyethyl adipate	$C_{14}H_{26}O_6$ $C_2H_5OC_2H_4OCO(CH_2)_4COOC_2H_4OC_2H_5$	290	1.036@25°	1.439@ 25°	—	—	<−70	—	0.248	—	8
Di-(methylcyclohexyl) adipate	$C_{20}H_{34}O_4$ $CH_3C_6H_{10}OCO(CH_2)_4COOC_6H_{10}CH_3$	338	1.091@20°	1.4685@ 20°	—	200–230@ 12 mm.	−45°	189	Insoluble	Sipalin AOM	7
BENZOIC ACID DERIVATIVES											
Methyl *o*-benzoyl benzoate	$C_{15}H_{12}O_3$ $C_6H_5COC_6H_4COOCH_3$	240	1.190@25°	1.587@ 25°	—	351	52	—	0.005	—	8
Ethyl *o*-benzoyl benzoate	$C_{16}H_{14}O_3$ $C_6H_5COC_6H_4COOC_2H_5$	254	—	1.573@ 25°	—	—	58	—	0.010	Ketonone E	2, 8
BENZOPHENONE	$C_{13}H_{10}O$ $C_6H_5COC_6H_5$	182	1.111@25°	1.602@ 25°	—	305	48	—	0.006	—	8
CAMPHOR	$C_{10}H_{16}O$ $CH_2CH_2CHC(CH_3)_2C(CH_3)COCH_2$	152	1.000@25°	—	38@18°	204	178	93	0.170	—	8
CITRIC ACID DERIVATIVES											
Triethyl citrate	$C_{12}H_{20}O_7$ $(C_2H_5OCOCH_2)_2C(OH)COOC_2H_5$	276	1.136@25°	1.4405@ 24.5°	—	150@ 3 mm.	—	155	6.1@20°	—	14
Tri-*n*-butyl citrate	$C_{18}H_{32}O_7$ $(C_4H_9OCOCH_2)_2C(OH)COOC_4H_9$	360	1.042@25°	1.4431@ 25°	—	220–225@ 4–5 mm.	— <−55	182	0.008	—	5, 8, 14
Acetyl triethyl citrate	$C_{14}H_{22}O_8$ $(C_2H_5OCOCH_2)_2C(OCOCH_2)COOC_2H_5$	318	1.135@23°	1.4386@ 23°	—	—	—	—	—	—	14
Acetyl tri-*n*-butyl citrate	$C_{20}H_{34}O_8$ $(C_4H_9OCOCH_2)_2C(OCOCH_3)COOC_4H_9$	402	1.046@25°	1.4408@ 25.5°	—	—	—	—	Insoluble	—	14
CYCLOHEXANONE DERIVATIVES											
Methyl cyclohexanone glyceryl acetal	$C_9H_{16}O_3$ $C[OCH(CH_2OH)CH_2O](CH_2)_4CHCH_3$	172	1.074@20°	1.474@ 20°	—	130–140@ 20 mm.	—	113	Insoluble	Cyclonol	7
GLYCEROL DERIVATIVES											
Glycerol monoacetate	$C_5H_{10}O_4$ $CH_3COOCH_2CHOHCH_2OH$	134	1.206@20°	1.4535	—	158 @ 165 mm.	40	148	∞	Acetin	8, 10
Glycerol diacetate	$C_7H_{12}O_5$ $C_3H_5(OH)(OCOCH_3)_2$	176	1.184@16°	—	—	176@ 40 mm.	—	146	∞	Diacetin	8
Glycerol triacetate	$C_9H_{14}O_6$ $CH_3COOCH_2CH(OCOCH_3)CH_2OCOCH_3$	218	1.161@20°	1.429@ 25°	—	259–262	−78	146	6.69@20°	Triacetin	8, 10
Glycerol tripropionate	$C_{12}H_{20}O_6$ $C_3H_5(OCOC_2H_5)_3$	260	1.078@20°	1.431@ 20°	—	177–182@ 20 mm.	<−50	—	0.313	Tripropionin	8
Glycerol tributyrate	$C_{15}H_{26}O_6$ $C_3H_5(OCOC_3H_7)_3$	302	1.035@20°	1.4359@ 20°	—	315	<−75	—	0.010	Tributyrin	8
GLYCOL DERIVATIVES											
Ethylene glycol diacetate	$C_6H_{10}O_4$ $(CH_3OCOCH_3)_3$	146	1.104@20°	1.414@ 25°	—	186	<−70	104	1.815	Ethylene diacetate	8
Ethylene glycol dipropionate	$C_8H_{14}O_4$ $(CH_2OCOC_2H_5)_2$	174	1.054@15°	1.419@ 25°	—	211	<−80	—	0.160	Ethylene dipropionate	8
Ethylene glycol dibutyrate	$C_{10}H_{18}O_4$ $(CH_2OCOC_3H_7)_2$	202	1.024@0°	1.424@ 25°	—	240	<−80	—	0.050	Ethylene dibutyrate	8
Diethylene glycol diacetate	$C_8H_{14}O_5$ $(CH_3COOCH_2CH_2)_2{:}O$	190	1.116@20°	—	0.02	250	—	135	∞	—	8
Diethylene glycol dipropionate	$C_{10}H_{18}O_5$ $(CH_3CH_2COOCH_2CH_2)_2{:}O$	218	1.066@20°	1.429@ 25°	—	114–140@ 4 mm.	—	127	3.60	KP-45	13
Triethylene glycol diacetate	$C_{10}H_{18}O_6$ $(CH_2OCH_2CH_2OCOCH_3)_2$	234	1.112@25°	1.437@ 25°	—	300	<−60	—	>50	—	8
Triethylene glycol dipropionate	$C_{12}H_{22}O_6$ $(CH_2OCH_2CH_2OCOC_2H_5)_2$	262	1.066@25°	1.436@ 25°	—	138–142@ 2 mm.	<−60	—	6.70	—	8
Triethylene glycol dibutyrate	$C_{14}H_{26}O_6$ $(CH_2OCH_2CH_2OCOC_3H_7)_2$	290	1.033@25°	1.437@ 25°	—	151–160@ 2 mm.	<−70	—	0.800	—	8
Triethylene glycol di-2-ethylbutyrate	$C_{18}H_{34}O_6$ $C_5H_{11}CO(OC_2H_4)_3OCOC_5H_{11}$	346	0.995@25°	—	<0.1	358	—	196	1.09	"Flexol" plasticizer 3GH	4
Triethylene glycol di-2-ethylhexoate	$C_{22}H_{42}O_6$ $C_7H_{15}CO(OC_2H_4)_3OCOC_7H_{15}$	402	0.968@25°	—	—	215@ 5 mm.	—	207	—	"Flexol" plasticizer 3GO	4
GLYCOLIC ACID DERIVATIVES											
Methyl phthalyl ethyl glycolate	$C_{13}H_{14}O_6$ $CH_3OCOC_6H_4COOCH_2COOC_2H_5$	266	1.220@25°	1.504@ 25°	—	189@ 5 mm.	—	193	0.053	Santicizer M-17	11
Ethyl phthalyl ethyl glycolate	$C_{14}H_{16}O_6$ $C_2H_5OCOC_6H_4COOCH_2COOC_2H_5$	280	1.180@25°	1.498@ 25°	—	190@ 5 mm.	—	195	0.050	Santicizer E-15	11
Butyl phthalyl butyl glycolate	$C_{18}H_{24}O_6$ $C_4H_9OCOC_6H_4COOCH_2COOC_4H_9$	336	1.097@25°	1.490@ 25°	—	219@ 5 mm.	—	199	0.018	Santicizer B-16	11
NAPTHALENE DERIVATIVES											
Diamylnaphthalene	$C_{20}H_{28}$ $C_{10}H_6(C_5H_{11})_2$	268	0.93–4@20°	1.5535@ 20°	0.0012@20°	326–375	—	163	Insoluble	—	16
OLEIC ACID DERIVATIVES											
Methoxy ethyl oleate	$C_{21}H_{40}O_3$ $C_8H_{17}CH{=}CH(CH_2)_7COOC_2H_4OCH_3$	340	0.902@20°	—	—	195–225@ 4 mm.	—	182	Insoluble	Kapsol Methyl "Cellosolve" oleate	13
PENTAERYTHRITOL DERIVATIVES											
Pentaerythritol tetra acetate	$C_{13}H_{20}O_8$ $C(CH_2OCOCH_3)_4$	304	—	1.54–6@ 20°	—	276@ 30 mm.	257	—	5.27@15°	—	12
PHTHALIC ACID DERIVATIVES											
Dimethyl phthalate	$C_{10}H_{10}O_4$ $C_6H_4(COOCH_3)_2$	194	1.193@25°	1.513@ 25°	<0.01	282	0	154	0.305	—	4, 5, 8, 10, 11, 19
Diethyl phthalate	$C_{12}H_{14}O_4$ $C_6H_4(COOC_2H_5)_3$	222	1.118@25°	1.499@ 25°	—	295	−40	163	0.150	—	5, 8, 10, 11, 19
Dipropyl phthalate	$C_{14}H_{18}O_4$ $C_6H_4(COOC_3H_7)_2$	250	1.071@25°	1.494@ 25°	—	129–132@ 1 mm.	—	—	0.015	—	8
Dibutyl phthalate	$C_{16}H_{22}O_4$	278	1.050@25°	1.490@25°	<0.01	325	−35	168	0.013	—	2, 4, 5, 8

glycolate	$CH_3OCOC_6H_4COOCH_2COOC_2H_5$				25°	5 mm.					
Ethyl phthalyl ethyl glycolate	$C_{14}H_{16}O_6$ $C_2H_5OCOC_6H_4COOCH_2COOC_2H_5$	280	1.180@25°	1.498@ 25°	—	190@ 5 mm.	—	196	0.050	Santicizer E-15	11
Butyl phthalyl butyl glycolate	$C_{18}H_{24}O_6$ $C_4H_9OCOC_6H_4COOCH_2COOC_4H_9$	336	1.097@25°	1.490@ 25°	—	219@ 5 mm.	—	199	0.018	Santicizer B-16	11
NAPTHALENE DERIVATIVES											
Diamylnaphthalene	$C_{20}H_{28}$ $C_{10}H_6(C_5H_{11})_2$	268	0.93–4@20°	1.5535@ 20°	0.0012@20°	326–375	—	163	Insoluble	—	16
OLEIC ACID DERIVATIVES											
Methoxy ethyl oleate	$C_{21}H_{40}O_3$ $C_8H_{17}CH{=}CH(CH_2)_7COOC_2H_4OCH_3$	340	0.902@20°	—	—	195–225@ 4 mm.	—	182	Insoluble	Kapsol Methyl "Cellosolve" oleate	13
PENTAERYTHRITOL DERIVATIVES											
Pentaerythritol tetra acetate	$C_{13}H_{20}O_8$ $C(CH_2OCOCH_3)_4$	304	—	1.54–6@ 20°	—	276@ 30 mm.	257	—	5.27@15°	—	12
PHTHALIC ACID DERIVATIVES											
Dimethyl phthalate	$C_{10}H_{10}O_4$ $C_6H_4(COOCH_3)_2$	194	1.193@25°	1.513@ 25°	<0.01	282	0	154	0.305	—	4, 5, 8, 10, 11, 19
Diethyl phthalate	$C_{12}H_{14}O_4$ $C_6H_4(COOC_2H_5)_3$	222	1.118@25°	1.499@ 25°	—	295	−40	163	0.150	—	5, 8, 10, 11, 19
Dipropyl phthalate	$C_{14}H_{18}O_4$ $C_6H_4(COOC_3H_7)_2$	250	1.071@25°	1.494@ 25°	—	129–132@ 1 mm.	—	—	0.015	—	8
Dibutyl phthalate	$C_{16}H_{22}O_4$ $C_6H_4(COOC_4H_9)_2$	278	1.050@25°	1.490@25°	<0.01	325	−35	168	0.013	—	2, 4, 5, 8, 10, 11, 13, 19
Diamyl phthalate	$C_{18}H_{26}O_4$ $C_6H_4(COOC_5H_{11})_2$	306	1.022@25°	1.488@ 25°	—	342	<−55	171	0.010	—	5, 8, 10, 19
Dioctyl phthalate	$C_{24}H_{38}O_4$ $C_6H_4(COOC_8H_{17})_2$	390	0.984@20°	—	—	215–230@ 4 mm.	—	205	Insoluble	—	13
Diphenyl phthalate	$C_{20}H_{14}O_4$ $C_6H_4(COOC_6H_5)_2$	318	1.28@25°	1.572@ 74°	—	250–257@ 14 mm.	69	—	Insoluble	—	11
Dimethoxy ethyl phthalate	$C_{14}H_{18}O_6$ $C_6H_4(COOC_2H_4OCH_3)_2$	282	1.170@20°	1.500@ 25°	—	190–205@ 4 mm.	<−60	180	0.838	Methox Dimethyl "Cellosolve" phthalate	8, 13
Diethoxy ethyl phthalate	$C_{16}H_{22}O_6$ $C_6H_4(COOC_2H_4OC_2H_5)_2$	310	1.120@20°	1.492@ 25°	—	202–212@ 4 mm.	30	180	0.195	Ethox Di-"Cellosolve" phthalate	8, 13
Dibutoxy ethyl phthalate	$C_{20}H_{30}O_6$ $C_6H_4(COOC_2H_4OC_5H_9)_2$	366	1.063@20°	—	—	220–230@ 4 mm.	<−18	202	<0.1@25	Dibutyl "Cellosolve" phthalate Kronisol	8,13
Di-(diethylene glycol monoethyl ether) phthalate	$C_{20}H_{30}O_8$ $C_6H_4(COOCH_2CH_2OCH_2CH_2OC_2H_5)_2$	398	1.121@20°	—	—	235–255@ 14 mm.	<−17	208	ca. 1	Di-"Carbitol" phthalate	13
PHOSPHORIC ACID DERIVATIVES											
Trimethyl phosphate	$C_3H_9O_4P$ $(CH_3O)_3PO$	140	1.205–1.220 @20°	1.3953@ 20°	—	190–205	—	—	∞	—	5
Triethyl phosphate	$C_6H_{15}O_4P$ $(C_2H_5O)_3PO$	182	1.068–1.072 @20°	1.4055@ 20°	10@73°	210–220	—	—	∞	—	5
Tributyl phosphate	$C_{12}H_{27}O_4P$ $(C_4H_9O)_3PO$	266	0.973–0.983 @20°	1.4248@ 20°	—	289	<−20	146	0.033	—	5
Triphenyl phosphate	$C_{18}H_{15}O_4P$ $(C_6H_5O)_3PO$	326	1.185@25°	1.563@ 25°	—	220@ 5 mm.	48.5	225	0.002	—	6, 8, 11
Tricresyl phosphate	$C_{21}H_{21}O_4P$ $(CH_3C_6H_4O)_3PO$	368	1.175@20°	1.556@ 25°	—	295@ 13 mm.	<−35	230	0.008	Kronitex AA	8, 11, 13
Di-*p-tert.*-butylphenyl mono-phenyl phosphate	$C_{26}H_{31}O_4P$ $[(CH_3)_3CC_6H_4O]_2(C_6H_5O)PO$	438	1.11@25°	1.540@ 25°	—	260–275 @5 mm.	—	250	Insoluble	Dow Plasticizer 2	6
Tri-*p-tert.*-butylphenyl phosphate	$C_{30}H_{39}O_4P$ $(CH_3)_3CC_6H_4O]PO$	495	—	—	—	320@ 5 mm.	103–105	275	Insoluble	Dow Plasticizer 7	6
Di-phenyl mono-*o*-xenyl phosphate	$C_{24}H_{19}O_4P$ $(C_6H_5O)_2(C_6H_5C_6H_4O)PO$	402	1.20@60°	1.582–90 @60°	—	250–285@ 5 mm.	—	225	Insoluble	Dow Plasticizer 5	6
Di-*o*-xenyl mono-phenyl phosphate	$C_{30}H_{23}O_4P$ $(C_6H_5C_6H_4O)_2(C_6H_5O)PO$	478	1.20@60°	1.603–5@ 60°	—	285–330@ 5 mm.	—	250	Insoluble	Dow Plasticizer 6	6
Di-*p-tert.*-butylphenyl mono-5-*tert.*-butyl-2-xenylphosphate	$C_{36}H_{43}O_4P$ $[(CH_3)_3CC_6H_4O]_2[(CH_3)_3C(C_6H_5)C_6H_3O]PO$	570	1.07@60°	1.546@ 60°	—	300–325@ 5 mm.	—	275	Insoluble	Dow Plasticizer 11	6
RICINOLEIC ACID DERIVATIVES											
n-Butyl acetyl ricinoleate	$C_{24}H_{44}O_4$ $C_{17}H_{32}(OCOCH_3)(COOC_4H_9)$	396	0.940@20°	1.4614@ 20°	—	220–235@ 3–5 mm.	−32 −65	110	Insoluble	—	5
SEBACIC ACID DERIVATIVES											
Diethyl sebacate	$C_{14}H_{26}O_4$ $C_2H_5OCO(CH_2)_8COOC_2H_5$	258	1.048@25°	1.419@	— 25°	308	1.3	—	0.190	—	8
Dibutyl sebacate	$C_{18}H_{34}O_3$ $C_4H_9OCO(CH_2)_8COOC_4H_9$	314	0.936–0.942 @25°	1.4391@ 20°	—	344–5	—	178	<0.1	—	1, 15
Glycol sebacate	$(C_{12}H_{20}O_4)_n$ $[-CH_2CH_2OCO(CH_2)_8COO-]_n$	$(228)_n$	—	—		—	—	—	—	Paraplex —	15
STEARIC ACID DERIVATIVES											
n-Butyl stearate	$C_{32}H_{44}O_2$ $C_{17}H_{35}COOC_4H_9$	340	0.855–0.862 @25°	1.4446@ 20°	—	220–5@ 25 mm.	ca. 20	183	0.2	—	5, 10
Butoxy ethyl stearate	$C_{24}H_{48}O_3$ $C_{17}H_{35}COOC_2H_4OC_4H_9$	384	0.885@20°	—	—	214–230@ 4 mm.	16.5	193	Insoluble	Butyl "Cellosolve" stearate KP-23	13
SUCCINIC ACID DERIVATIVES											
Diethyl succinate	$C_8O_{14}O_4$ $C_2H_5OCOCH_2CH_2COOC_2H_5$	174	1.048@25°	1.419@ 25°	—	218	−22	—	0.190	—	8
Dibutyl succinate	$C_{12}H_{22}O_4$ $C_4H_9OCOCH_2CH_2COOC_4H_9$	230	0.974@25°	1.428@ 25°	—	255	−19	—	0.023	—	8
SUCROSE DERIVATIVES											
Sucrose octa acetate	$C_{28}H_{38}O_{19}$ $C_{12}H_{14}O_3(OCOCH_3)_8$	678	1.28@20°	—	—	260@ 0.1 mm.	79–86	—	0.09	—	12
TARTARIC ACID DERIVATIVES											
Diethyl tartrate	$C_8H_{14}O_6$ $C_2H_5OCO(CHOH)_2COOC_2H_5$	206	1.99@25°	1.445@ 25°	—	280	17	—	>50	—	8
Dibutyl tartrate	$C_{12}H_{22}O_6$ $C_4H_9OCO(CHOH)_2COOC_4H_9$	262	1.086@25°	1.445@ 25°	—	292–312	21	110	0.485	—	5, 8, 10
TOLUENESULFONIC ACID DERIVATIVES											
o-Cresyl *p*-toluenesulfonate	$C_{14}H_{14}O_3S$ $CH_3C_6H_4SO_2OC_6H_4CH_3$	262	1.207@25°	1.558@ 25°	—	—	52.5	—	0.003	Santicizer 10	11
Cyclohexyl *p*-toluenesulfonamide	$C_{13}H_{19}O_2NS$ $CH_3C_6H_4SO_2NHC_6H_{11}$	253	—	1.542@ 25°	—	—	86	—	0.006	Santicizer 1-H	11
o- and *p*-Toluenesulfonamide	$C_7H_9O_2NS$ $CH_3C_6H_4SO_2NH_2$	171	1.313@25°	—	—	—	105	—	ca. 1	Santicizer 9	11
o- and *p*-Toluene ethylsulfonamide	$C_9H_{13}O_2NS$ $CH_3C_6H_4SO_2NHC_2H_5$	199	1.190@25°	1.540@ 25°	—	—	18	—	0.140	Santicizer 8	11
TRICARBALLYLIC ACID DERIVATIVES											
Triethyl tricarballylate	$C_{12}H_{20}O_6$ $(C_2H_5OCOCH_2)_2CHCOOC_2H_5$	260	1.087@20°	1.4324@ 26°	—	158–60@ 5 mm.	—	—	0.62@20°	—	14
Tri-*n*-butyl tricarballylate	$C_{18}H_{32}O_6$ $(C_4H_9OCOCH_2)_2CHCOOC_4H_9$	344	1.004@24°	1.4388@ 26.5°	—	305	—	—	Insoluble	—	14

List of Manufacturers of Solvents and Plasticizers

1. Amecco Chemicals, Inc., 75 Rockwood Street, Rochester, N. Y.
2. American Cyanamid and Chemical Corp., 30 Rockefeller Plaza, New York, N. Y.
3. Barrett Company, 40 Rector Street, New York, N. Y.
4. Carbide and Carbon Chemicals Corp., 30 East 42nd Street, New York, N. Y.
5. Commercial Solvents Corp., Terre Haute, Ind.
6. Dow Chemical Co., Midland, Mich.
7. E. I. du Pont de Nemours and Co., Wilmington, Del.
8. Eastman Kodak Co., Chemical Sales Div., Rochester, N. Y.
9. Hercules Powder Co., Wilmington, Del.
10. Kessler Chemical Corp., 239 Eleventh Ave., New York, N. Y.
11. Monsanto Chemical Co., St. Louis, Missouri
12. Niacet Chemicals Corp., Niagara Falls, N. Y.
13. Ohio-Apex, Incorporated, Nitro, West Virginia
14. Charles Pfizer and Co., Inc., 11 Bartlett Street, Brooklyn, N. Y.
15. Resinous Products and Chemical Co., Inc., 222 W. Washington Sq., Philadelphia, Pa.
16. Sharples Solvents Corp., 23rd and Westmoreland Sts., Philadelphia, Pa.
17. Standard Oil Co. of New Jersey, New York, N. Y.
18. The Quaker Oats Co., Chicago, Ill.
19. U. S. Industrial Chemicals, Inc., 60 East 42nd St., New York, N. Y.

Note. The Solvents Chart is located opposite page 424.

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Nomenclature

Aminoplast—General terms for synthetic resins from amino or amido compounds. A typical example is urea-formaldehyde resin.

Amorphous—Devoid of crystalline structure.

Asphalt—A dark-colored, viscous to solid hydrocarbon complex including: (a) The easily fusible bitumens often associated with a mineral matrix, not having a waxy luster or unctuous feel; (b) fusible residuums obtained from the distillation, oxidation, etc., of bitumens.

A-Stage resins—Thermosetting resins reacted only to the initial stage where they are soluble and fusible. The normal stage of a resin used for impregnation.

Balsams—Natural vegetable exudations consisting of resins mixed with volatile oil. The name is also applied to products having the physical characteristics of the natural balsams but produced by reactions which normally lead to resinous materials.

Bitumen—A naturally occurring or pyrogenous hydrocarbon complex insoluble in water but soluble in carbon disulphide. Color and hardness variable.

B-Stage resins—Thermosetting resins reacted to a stage where they soften when heated and swell in contact with liquids but do not entirely fuse or dissolve. This is the preferred stage for the resin in molding compositions.

Bulk factor—The ratio by volume of the loose molding powder to the resultant finished article.

Cold flow—Change of dimensions or distortion caused by sustained application of a force greater than the elastic limit.

Cold molding—A procedure in which a composition is shaped at ordinary temperatures and hardened by subsequent baking.

Colloid—Any substance when dispersed into particles whose size ranges between 5 and 100 millimicrons. Molecules of many synthetic resins fall within this range.

Condensation—A chemical reaction in which two or more molecules combine with separation of water or some other simple substance. Applied to synthetic resins it means the formation of a resin by combination of a number of molecules with elimination of water, ammonia, hydrogen chloride or other simple substance. Examples of condensation resins are alkyd, phenol-aldehyde and urea-formaldehyde resins. The final products are also called condensation-polymers. *See Polymerization.*

Co-polymerization—The term applied when two or more substances polymerize at the same time to yield a product which is not a mixture of separate polymers but a complex having properties different from either polymer alone. Thus, Vinylite copolymer is produced by polymerization of a mixture of vinyl acetate and vinyl chloride.

C-Stage resins—Thermosetting resins in the final stage in which they are infusible and insoluble. The state of the resin in the final molded article.

Curing—The change of a binder from the soluble-fusible condition to the substantially insoluble-infusible form by chemical action. The heat-setting of a resinoid. Action is analogous to vulcanization of rubber.

Dielectric strength—Voltage gradient at which a continuous electrical discharge will take place between two electrodes when the material in question is placed between the electrodes and a potential difference is applied to them.

Elastic deformation—One in which a substance reverts to its original dimensions on release of an applied stress.

Elastic limit—The point at which a body begins to yield under a stress; that is, when the stress is equal to or greater than the internal friction.

Eucolloids—Linear polymers of a degree of polymerization over 1000; that is, each molecule is made up of over 1000 units of a simple substance. They show pronounced swelling and their solutions are highly viscous. The solid eucolloids are very tough and hard.

Extrusion molding—A molding procedure for extended shapes of uniform cross-section, whereby a heat-softened substance is forced through an orifice of form coinciding with the cross-section of the article.

Flash mold—A mold designed to permit excess molding material to escape during final closing.

Fluidity—Reciprocal of the viscosity.

Gel—A somewhat rigid, generally transparent, two-phase liquid-solid system in which the solid is precipitated as aggregates in and around which the liquid is held.

Gelation—Formation of a gel.

Gums—Viscous vegetable secretions which harden but, unlike resins, are water-soluble. The name is often applied, particularly in the varnish industry, to natural resins such as copals.

Hemicolloids—Polymers of molecular weight up to 10,000, corresponding to an order of polymerization equal to 20 to 100 monomeric units. They dissolve without swelling and give solutions of low viscosity. Precipitation from solution yields powdery masses.

Injection molding—A molding procedure whereby a heat-softened plastic material is forced from a receptacle into a relatively cool cavity which gives the article of desired shape.

Laminated products—Sheets of material united by a binder. For example, sheets of paper or wood coated and/or impregnated with a resinous composition and subjected to pressure, generally with heat.

Lastic—A substance which at a certain temperature

exhibits the physical properties of rubber. Unlike a viscous liquid, stress causes deformation at this temperature but removal of stress results in substantial recovery of the original shape.

Linear molecule—A molecule of highly elongated form. Generally applied to straight-chain polymers.

Loss factor—The product of the power factor and the dielectric constant.

Macromolecule—A molecule of such size that it exhibits colloidal properties.

Mesocolloids—Polymers intermediate between hemicolloids and eucolloids; that is, of a degree of polymerization between about 100 and 1000.

Modulus of elasticity—The stress required to produce a unit distortion.

Monomer—The simplest repeating structural unit of a polymer. For addition polymers this represents the originally unpolymerized compound.

Natural resins—Solid substances from vegetable excretions exhibiting brittleness, vitreous luster, conchoidal fracture, water-insolubility and varying fusibility and solubility.

Novolak—A permanently fusible and soluble phenol-aldehyde resin. More specifically it is the reaction-product of 1 molecule of phenol with less than 1 molecule of formaldehyde, and an acid catalyst.

Phenoplast—A general term for phenol-aldehyde resins. Synonymous with popular term "phenolics."

Pitch—A dark-colored, fusible, more or less viscous to solid bituminous or resinous substance, insoluble in water but more or less soluble in carbon disulfide, benzol, etc. Composition and origin variable.

Plastic flow—Flow which is proportional to the pressure in excess of a certain minimum pressure (yield value) necessary to start the flow.

Plastics—All substances that can be molded. In general a plastic is a substance which behaves as a solid at stresses less than a certain amount known as the yield value and as a viscous liquid at stresses greater than this. The name is also applied to substances which originally but not ultimately fulfill this condition. For example, it is applied to thermoset compositions or resinoids in the final stages.

Plasticity—Susceptibility to and the retention of deformation. Capacity of taking and retaining the form of a mold. The property of solids by virtue of which they hold their shape permanently under the action of small shearing stresses but are readily deformed, worked or molded under larger stresses.

Polymerization—A chemical change resulting in the formation of a new compound whose molecular weight is a multiple of that of the original substance. The products of the reaction are called polymers. To distinguish from those resulting from condensation (q.v.), they are often designated addition polymers since the reaction is that of successive addition of a large number of relatively small molecules (monomers) to form the final polymer.

Positive mold—A mold designed to trap all the molding material to prevent its escape when it closes.

Power factor—In an insulating material, the ratio of total power loss (watts) in the material to the product of voltage and current in a capacitor in which that material is a dielectric.

Resin—A term generally referring to a physical condition at room temperature approximating the physical properties of natural resins (q.v.).

Resinoids—The class name applied to thermosetting resins. Temporary thermoplastics. The name is also often applied to the final cured resins.

Resite—A phenol-aldehyde resin in the C-stage (q.v.).

Resitol—A name often applied to a phenol-aldehyde resin in the B-stage (q.v.).

Resol—A name often applied to a potentially hardening phenol-aldehyde resin in the A-stage (q.v.).

Sol—A colloidal dispersion whose particles have sufficient Brownian motion to keep them in suspension.

Synthetic resin—A complex, substantially amorphous, organic semi-solid or solid material (usually a mixture of substances) built up by chemical reaction of comparatively simple compounds and, depending upon the temperature at which the examination is made, approximating the natural resins in various physical properties, namely: luster, fracture, comparative brittleness, insolubility in water, fusibility or plasticity when heated or exposed to heat and pressure, and, at a certain more or less narrow temperature range before fusion, showing a degree of rubber-like extensibility; but commonly deviating widely from natural resins in chemical constitution and behavior with reagents.

Synthetic rubber—Caoutchouc synthesized in the laboratory. The term is a misnomer and most probably represents an impossibility.

Tars—Dark-colored substances, liquid or semi-liquid at room temperature often possessing a characteristic "tarry" odor, usually insoluble in water but soluble in carbon disulfide, benzol, etc., and which on distillation, oxidation, etc., form a pitch. Composition variable.

Thermoplastic—The property of softening under heat. All molding materials are thermoplastic at the initial application of heat. One class (the so-called thermoplastics) remains soft permanently under heat; the other (thermosetting), after first softening, sets or cures more or less quickly to a more solid form.

Thermosetting—The property of undergoing a chemical change when heated whereby a hardened product is obtained. Property most pronounced in phenol- and urea-formaldehyde resins and less so with alkyds.

Thixotropy—The property by which some compositions become solid at rest but liquefy again on agitation.

Transfer molding—Another name for injection molding of thermosetting materials.

Treacle stage—A thermosetting resin in liquid form. Particularly applied to casting.

Viscosity—Internal friction or resistance to change of form of a liquid. The constant ratio of shearing stress to rate of shear.

Yield value—The lowest pressure at which a plastic will flow. Below this pressure the plastic behaves as an elastic solid; above this pressure as a viscous liquid.

PLASTICS AND RAW MATERIALS

USED IN MANUFACTURING PLASTIC COMPOSITIONS

ACIDS

American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
Baker Castor Oil Co.
Baker Chemical Co., J. T.
Cliff Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
General Chemical Co.
Harshaw Chemical Co.
Hercules Powder Co.
Kay-Fries Chemical Supplies, Inc.
Koppers Co.
Mallinckrodt Chemical Works
Monsanto Chemical Co.
National Aniline & Chemical Co., Inc.
National Oil & Supply Co.
Niacet Chemicals Corp.
Pacific Coast Borax Co.
Penn Salt Mfg. Co.
Reilly Tar & Chemical Corp.

ALDEHYDE AMMONIA

du Pont de Nemours & Co., Inc., E. I.
Niacet Chemicals Corp.

CAMPHOR

du Pont de Nemours & Co., Inc., E. I.
Insel Co., The
Mallinckrodt Chemical Works

CASEIN

American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
American Plastics Corp.
Hercules Powder Co.
Innis, Speiden & Co., Inc.
Kay-Fries Chemical Supplies, Inc.
Merchants Chemical Co., Inc.
Merck & Co., Inc.

CASEIN

(Rods-Sheets-Tubes)

American Plastics Corp.
Morrell Corp., George

CELLULOSE ACETATE

(Flake)

American-British Chemical Supplies, Inc.
American Cellulose Co.
Bakelite Corp.
Hercules Powder Co.
Meyer & Co., W. & G.
Monsanto Chemical Co.
Tennessee Eastman Corp.

CELLULOSE ACETATE

(Rods-Sheets-Tubes)

American Cellulose Co.
American Prod. Mfg. Co. (sheets only)
Auburn Button Works, Inc.
Celluloid Corp.
Cinelin Company
du Pont de Nemours & Co., Inc., E. I.
Eastman Kodak Co.
Insel Co.
Kay-Fries Chemical Supplies, Inc.
Monsanto Chem. Co., Plastics Div.
Nixon Nitration Works

CELLULOSE NITRATE

(Rods-Sheets-Tubes)

American Cellulose Co.
Auburn Button Works, Inc.
Celluloid Corp.
Cinelin Company
du Pont de Nemours & Co., Inc., E. I.
Eastman Kodak Co.
Insel Co.
Mallinckrodt Chemical Works
Monsanto Chem. Co., Plastics Div.
Nixon Nitration Works
Sylvania Industrial Corp.

CELLULOSE NITRATE

(Nitrocotton)

American Cellulose Co.
American Cyanamid & Chemical Corp.
General Chemical Co.
Hercules Powder Co.
Monsanto Chemical Co., Plastics Div.

CHLORINATED RUBBER

Hercules Powder Co.

COLORS

(See Dyes; Pigments)

DENTURE MATERIALS

Auburn Button Works, Inc.
Bakelite Corp.
Carbide & Carbon Chemicals Corp.
Celluloid Corp.
du Pont de Nemours & Co., Inc., E. I.
Monsanto Chem. Co., Plastics Div.
Nixon Nitration Works
Peters Chemical Mfg. Co.
Röhm & Haas Co.
Schwab & Frank, Inc.

DYES

American Aniline Products, Inc.
Calco Chemical Division, American Cyanamid Co.
Ciba Co., Inc.
Dow Chemical Co.
Drakenfeld & Co., Inc.
du Pont de Nemours & Co., Inc., E. I.
Monsanto Chemical Co.
National Aniline & Chemical Co., Inc.

ETHYLCELLULOSE

American Cellulose Co.
American Products Mfg. Co.
Dow Chemical Co.
Hercules Powder Co.

FILLERS, ALPHA CELLULOSE

Brown Co.
Caffelite Corp.
Connor Lumber & Land Co., The
Weller Chemical Co.

FILLERS, COTTON FLOCK

Becker, Moore & Co., Inc.
Claremont Waste Mfg. Co.
Composition Materials Co., Inc.
Peckham Mfg. Co., The
Rayon Processing Co. of R. I.
Weller Chemical Co.

FILLERS, DIATOMACEOUS

Dicalite Co.
Harshaw Chemical Co., The
Johns-Manville
Wishnick-Tumpeer, Inc.

FILLERS, MINERAL

American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
Dicalite Co.
International Pulp Co.
Johns-Manville
Vermont Asbestos Mines, Div. of The Ruberoid Co.
Williams & Co., C. K.
Wishnick-Tumpeer, Inc.

FILLERS, SILICA

Dicalite Co.
International Pulp Co.
Johns-Manville
Loomis Talc Corp., W. H.
Monsanto Chemical Co.
Williams & Co., C. K.

FILLERS, WOODFLOUR

American Woodflour Co., Inc.
Becker, Moore & Co.
Burnet Co., The
Composition Materials Co., Inc.
Connor Lumber and Land Co.
Doe & Ingalls, Inc.
du Pont de Nemours & Co., Inc., E. I.
Innis, Speiden & Co., Inc.
Lignum Chemical Works, The
Soberski, B. L.
State Chemical Co.
Weller Chemical Co.
Wishnick-Tumpeer, Inc.

FORMALDEHYDE

American Cyanamid & Chemical Corp.
Ciba Co., Inc.
du Pont de Nemours & Co., Inc., E. I.
General Chemical Co.
Harshaw Chemical Co.
Hercules Powder Co.
Heyden Chemical Corp.
Kay-Fries Chemical Supplies, Inc.
Mallinckrodt Chemical Works
Merck & Co., Inc.
National Oil & Supply Co.

HEXAMETHYLENETETRAMINE

American-British Chemical Supplies, Inc.
Baker Chemical Co., J. T.
du Pont de Nemours & Co., Inc., E. I.
Heyden Chemical Corp.
Kay-Fries Chemical Supplies, Inc.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Wishnick-Tumpeer, Inc.

LACQUERS, CELLULOSE AND RESINOUS

American Products Mfg. Co.
Bakelite Corp.
Caffelite Corp.
Catalin Corp.
du Pont de Nemours & Co., Inc., E. I.
Durez Plastics & Chemicals, Inc.

Durite Plastics, Inc.
Eastman Kodak Co.
Egyptian Lacquer Mfg. Co.
Heresite & Chemical Co.
Irvington Varnish & Insulator Co.
Maas & Waldstein Co.
Manufacturers Chemical Corp.
Masury & Son, John W.
Monsanto Chemical Co.
Pyroxylin Products, Inc.
Resinous Products & Chemical Co.
Roxalin Flexible Lacquer Co., Inc.
Stanley Chemical Co.

METHYL METHACRYLATE

(Rods-Sheets-Tubes)

du Pont de Nemours & Co., Inc., E. I.
Röhm & Haas Co.

(Solutions)

Peters Chemical Mfg. Co.
Resinous Products & Chemical Co.
Schwab & Frank, Inc.

MICA

American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
Harshaw Chemical Co.
Maryland Chemical Co.
Mica Insulator Co.
Munsell & Co., Eugene
Uhlich & Co., Inc., Paul
Westinghouse Elec. & Mfg. Co.
Wishnick-Tumpeer, Inc.

MOLDING & LAMINATING BOARDS AND BLANKS

Bakelite Corp.
Bakelite-Rogers Co., Inc.
Dispersion Products, Inc.
Heresite & Chemical Co.
Mica Insulator Co.
Taylor-Atkins Paper Mills
Westinghouse Elec. & Mfg. Co.

MOLDING COMPOUNDS, CELLULOSE ACETATE

Bakelite Corp.
Celluloid Corp.
du Pont de Nemours & Co., Inc., E. I.
Manufacturers Chemical Corp.
Monsanto Chem. Co., Plastics Div.
Nixon Nitration Works
Tennessee Eastman Corp.

MOLDING COMPOUNDS, CELLULOSE ACETATE BUTYRATE

Nixon Nitration Works
Tennessee Eastman Corp.

MOLDING COMPOUNDS, ETHYLCELLULOSE

Dow Chemical Co.
Insel Co., The
Manufacturers Chemical Corp.
Nixon Nitration Works

MOLDING COMPOUNDS, METHYL METHACRYLATE

du Pont de Nemours & Co., Inc., E. I.
Peters Chemical Mfg. Co.
Röhm & Haas Co.

MOLDING COMPOUNDS, PHENOL-FORMALDEHYDE

Bakelite Corp.
Catalin Corp.
Durez Plastics & Chemicals, Inc.
Durite Plastics, Inc.
Heresite & Chemical Co.
Irvington Varnish & Insulator Co.
A. Knoedler Co.
Makalot Corp.
Monsanto Chemical Co., Plastics Div.
Plastex Corp. Ltd., The
Reilly Tar & Chemical Corp.
Resinox Corp., Sub., Monsanto Chemical Co.

MOLDING COMPOUNDS, PHENOL-FURFURAL

Durite Plastics, Inc.

MOLDING COMPOUNDS, STYRENE

Bakelite Corp.
Carbide & Carbon Chemicals Corp.
Catalin Corp.
Dow Chemical Co.
Monsanto Chemical Co., Plastics Div.

MOLDING COMPOUNDS, UREA-FORMALDEHYDE

Bakelite Corp.
Beetle Prods. Div., of American Cyanamid Co.
Heresite & Chemical Co.
Plaskon Co., Inc.
Resinous Products & Chemical Co.

MOLDING COMPOUNDS, VINYL RESINS

Carbide & Carbon Chemicals Corp.
Monsanto Chem. Co., Plastics Div.
Nixon Nitration Works
Resistoflex Corp.
Shawinigan Prods. Corp.

NAPHTHALENE

American-British Chemical Supplies, Inc.
Barrett Company
Calco Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
Harshaw Chemical Co.
Koppers Co., Tar & Chemical Div.
Merchants Chemical Co., Inc.
National Oil & Supply Co.
Reilly Tar & Chemical Corp.

NITROCELLULOSE

(See Cellulose Nitrate)

PAPER, SATURATING

Bakelite Corp.
Catalin Corp.
Hurlbut Paper Co.
Keasbey & Mattison
Warren Co., S. D.

PARAFORMALDEHYDE

American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
du Pont de Nemours & Co., Inc., E. I.
Harshaw Chemical Co.
Heyden Chemical Corp.
Mallinckrodt Chemical Works
Merck & Co., Inc.

PEARL ESSENCE

Celluloid Corp.
Hudson Pearl Co.
Mearl Corp., The
Meyer Bros. Co., Jos. H.
Paispearl Products

PHENOLS

American-British Chemical Supplies, Inc.
Baker Chemical Co., J. T.
Barrett Company
Calco Chemical Division, American Cyanamid Co.
Catalin Corp.
Dow Chemical Co.
Durez Plastics and Chemicals, Inc.
Kay-Fries Chemical Supplies, Inc.
Koppers Co., Tar & Chemical Div.
Mallinckrodt Chemical Works
Merchants Chemical Co., Inc.
Merck & Co., Inc.
Monsanto Chemical Co.
Reilly Tar & Chemical Corp.
Sharples Solvents Corp.

PIGMENTS

Binney & Smith Co.
Cabot, Inc., Godfrey L.
Calco Chemical Division, American Cyanamid Co.
Chemical & Pigment Co., Inc.
Dow Chemical Co.
Drakenfeld & Co., Inc., B. F.
Drug Leaders, Inc.
du Pont de Nemours & Co., Inc., E. I.
Harshaw Chemical Co., The
International Pulp Co.
Johns-Manville
Uhlich & Co., Paul
Weller Chemical Co.
Williams & Co., C. K.
Wishnick-Tumpeer, Inc.

PLASTICIZERS

American Cyanamid & Chemical Corp.
Baker Castor Oil Co.
Carbide & Carbon Chemicals Corp.
Celluloid Corp.
Commercial Solvents Corp.
Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
Glyco Products Co., Inc.
Halowax Corp.
Hercules Powder Co.
Insel Co., The
Kay-Fries Chemical Supplies, Inc.
Metasap Chemical Co.
Monsanto Chemical Co.
National Aniline & Chemical Co., Inc.
National Oil Products Co.
Niacet Chemicals Corp
Ohio-Apex, Inc.
Pfizer & Co., Inc., Chas.
Resinous Products & Chemical Co.
U. S. Industrial Chemicals, Inc.

PRINTING PLATE MOLDING BOARD

Bakelite Corp.
Dispersion Products, Inc.
Westinghouse Elec. & Mfg. Co.

PYROXYLIN

(See Cellulose Nitrate)

RESIN BONDS FOR PLYWOODS, VENEERS AND LAMINATES

Bakelite Corp.
Beetle Prods. Div., American Cyanamid Co.
Caffelite Corp.
Carbide & Carbon Chemicals Corp.
Catalin Corp.
du Pont de Nemours & Co., Inc., E. I.
Durez Plastics & Chemicals, Inc.
Durite Plastics, Inc.
Henderson, Paul P.
Hercules Powder Co.
Makalot Corp.
Marblette Corp.
Merritt Engineering & Sales Co., Inc.
Monsanto Chem. Co., Plastics Div.
Plaskon Co., Inc.
Plastex Corp., Ltd., The

Reichhold Chemicals, Inc.
Reilly Tar & Chemical Corp.
Resinous Products & Chemical Co.
Sandraleux Plastic Products

RESIN SOLUTIONS

American Cyanamid & Chemical Corp.
Bakelite Corp.
Beetle Prods. Div., American Cyanamid Co.
Caffelite Corp.
Carbide & Carbon Chemicals Corp.
Catalin Corp.
Durez Plastics & Chemicals, Inc.
Durite Plastics, Inc.
Halowax Corp.
Heresite & Chemical Co.
Makalot Corp.
Marblette Corp.
Metasap Chemical Co.
Monsanto Chem. Co., Plastics Div.
National Oil Products Co.
Peters Chemical Mfg. Co.
Plaskon Co., Inc.
Plastex Corp., Ltd., The
Pyroxylin Products, Inc.
Reichhold Chemicals, Inc.
Reilly Tar & Chemical Corp.
Resinous Products & Chem. Co.
Resistoflex Corp.
Röhm & Haas Co., Inc.
Superior Plastics Co.

RESINS, CAST

Bakelite Corp.
Cast Plastics, Inc.
Catalin Corp.
du Pont de Nemours & Co., Inc., E. I.
Heresite & Chemical Co.
Knoedler Co., A.
Marblette Corp.
Monsanto Chem. Co., Plastics Div.
Plastex Corp., Ltd., The
Röhm & Haas Co.

RESINS, GLYCEROL

American Cyanamid & Chemical Corp.
Caffelite Corp.
Glyco Products Co., Inc.
Makalot Corp.
Reichhold Chemicals, Inc.
Resinous Products & Chemical Co.

RESINS, OIL SOLUBLE

American Cyanamid & Chemical Corp.
Bakelite Corp.
Beetle Prods. Div., American Cyanamid Co.
Durez Plastics & Chemicals, Inc.
Durite Plastics, Inc.
Irvington Varnish & Insulator Co.
Makalot Corp.
Monsanto Chemical Co.
Neville Co.
Plastex Corp., Ltd., The
Reichhold Chemicals, Inc.
Resinous Products & Chemical Co.
Resinox Corp., Sub. Monsanto Chemical Co.
Varcum Chemical Corp.

RESINS, PHENOL

American Cyanamid & Chemical Corp.
Bakelite Corp.
Barrett Co.
Catalin Corp.
Continental-Diamond Fibre Co.
Durez Plastics & Chemicals, Inc.
Durite Plastics, Inc.
Heresite & Chemical Co.
Irvington Varnish & Insulator Co.
Makalot Corp.
Marblette Corp.
Monsanto Chem. Co., Plastics Div.
Plastex Corp., Ltd., The
Reichhold Chemicals, Inc.
Reilly Tar & Chemical Corp.
Resinous Products & Chemical Co.
Resinox Corp.
Superior Plastics Co.
Varcum Chemical Corp.

RESINS, UREA

American Cyanamid & Chemical Corp.
Bakelite Corp.
Beetle Prods. Div., American Cyanamid Co.
Heresite & Chemical Co.
Makalot Corp.
Plaskon Co., Inc.
Reichhold Chemicals, Inc.
Resinous Products & Chemical Co.

RESINS, VARNISH MAKING

American Cyanamid & Chemical Corp.
Bakelite Corp.
Barrett Co.
Beetle Prods. Div., American Cyanamid Co.
Caffelite Corp.
Catalin Corp.
Continental-Diamond Fibre Co.
Durez Plastics & Chemicals, Inc.
Durite Plastics, Inc.
Hercules Powder Company
Heresite & Chemical Co.
Irvington Varnish & Insulator Co.
Makalot Corp.
Marblette Corp.
Monsanto Chemical Co.
Neville Co.
Plastex Corp., Ltd., The
Reichhold Chemicals, Inc.
Reilly Tar & Chemical Corp.
Resinous Products & Chemical Co.
Varcum Chemical Corp.

RESINS, VINYL

(Rods-Sheets-Tubes)

Carbide & Carbon Chemicals Corp.
du Pont de Nemours & Co., Inc., E. I.
Irvington Varnish & Insulator Co.
Monsanto Chem. Co., Plastics Div.
Resistoflex Corp.
Shawinigan Products Corp.

RESINS, WATER-SOLUBLE

American Cyanamid & Chemical Corp.
Bakelite Corp.
Beetle Prods. Div., American Cyanamid Co.
Catalin Corp.
Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
Durez Plastics & Chemicals, Inc.
Durite Plastics, Inc.
Glyco Products Co., Inc.
Hercules Powder Co.
Makalot Corp.
Marblette Corp.
Monsanto Chemical Co.
Plastex Corp., Ltd., The
Reichhold Chemicals, Inc.
Resinous Products & Chemical Co.

ROLL LEAF

(Stamping Foil)

Ackerman-Gould Corp.
Altair Machinery Corp.
Griffin, Campbell, Hayes, Walsh, Inc.
Kingsley Gold Stamping Machine Co.
Markem Machine Co.
Peerless Roll Leaf Co., Inc.
Simplex Gold Stamping Press Co., Inc.

ROSIN

Doe & Ingalls, Inc.
Hercules Powder Co.

RUBBER, SYNTHETIC MOLDING

American Hard Rubber Co.
Caffelite Corp.
Dow Chemical Co.
Irvington Varnish & Insulator Co.
Richardson Co., The
Stokes Rubber Co., Jos.
Thiokol Corp.

SCRAP, ACETATE

American Cellulose Co.
Atlantic Pyroxylin Waste Co.
Bamberger, A.
Burnet Co.
du Pont de Nemours & Co., Inc., E. I.
Eastman Kodak Co.
Gering Products, Inc.
Insel Co., The
Jefferys & Co., Ltd.
Monsanto Chem. Co., Plastics Div.
Paraloid Corp.
Sereinsky Co., Moses

SCRAP, NITRATE

American Cellulose Co.
American Pyroxylin Co.
Bamberger, A.
du Pont de Nemours & Co., Inc., E. I.
Eastman Kodak Co.
Gering Products, Inc.
Insel Co., The
Monsanto Chem. Co., Plastics Div.

SOLVENTS

American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
Barrett Co.
Calco Chemical Division, American Cyanamid Co.
Carbide & Carbon Chemicals Corp.
Commercial Solvents Corp.
Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
Hercules Powder Co.
Irvington Varnish & Insulator Co.
Kay-Fries Chemical Supplies, Inc.
Koppers Co.
Monsanto Chemical Co.
National Oil & Supply Co.
Neville Co.
Pfizer & Co., Inc., Chas.
Resinous Products & Chemical Co.
Sharples Solvents Corp.
U. S. Industrial Chemicals, Inc.

STEARATES

American Cyanamid & Chemical Corp.
Baker Chemical Co., J. T.
du Pont de Nemours & Co., Inc., E. I.
Glyco Products Co., Inc.
Harshaw Chemical Co.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Metasap Chemical Co.
National Oil Products Co.
Warwick Chemical Co.
Weller Chemical Co.
Wishnick-Tumpeer, Inc.

TALC

American Cyanamid & Chemical Corp.
Binney & Smith Co.
Drakenfeld & Co., Inc.
du Pont de Nemours & Co., Inc., E. I.
Harshaw Chemical Co.
Hercules Powder Co.
International Pulp Co.
Loomis Talc Corp., W. H.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Williams & Co., C. K.
Wishnick-Tumpeer, Inc.

UREA

Advance Solvents & Chemical Corp.
American Cyanamid & Chemical Corp.
Baker Chemical Co., J. T.
Ciba Co., Inc.
du Pont de Nemours & Co., Inc., E. I.
General Dyestuff Corp.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Sharples Solvents Corp.

MACHINERY, EQUIPMENT AND SUPPLIES

USED IN PRODUCING PLASTIC PRODUCTS

ABRASIVE MATERIALS

American Rotary Tools Co., Inc.
Carborundum Co.
Chicago Wheel & Mfg. Co.
Dicalite Co.
Lea Mfg. Co.
Minnesota Mining & Mfg. Co.
Norton Co., The
Pangborn Corp.
Porter-Cable Machine Co.
Production Machine Co.
Rogers, Wm. R.
Siebert, Rudolph R.

ACCUMULATORS

Adamson Machine Co., The
Albert & Son, L.
Aldrich Pump Co.
Babcock & Wilcox Co.
Baldwin-Southwark Division, Baldwin Locomotive Works
Bethlehem Steel Co.
Birdsboro Steel Foundry & Machine Co.
Burroughs Engineering Co.
Carver, Fred S.
Cavagnaro, John J.
Chambersburg Engineering Co.
Dunning & Boschert Press Co.
Elmes Engineering Works, Charles F.
Farrel Birmingham Co.
French Oil Mill Machinery Co.
Hydraulic Press Mfg. Co.
Lake Erie Engineering Corp.
Logemann Brothers Co.
Loomis Co., Evarts, G.
Martin, Frank M.
Robertson Co., Inc., John
Thropp & Sons Co., Wm. R.
Vickers, Inc.
Watson-Stillman Co.
Williams, White & Co.
Wood Co., R. D.

BEAD CHAINS

Bead Chain Mfg. Co.

BELTING, LEATHER

Dunning & Boschert Press Co.
Graton & Knight Mfg. Co.
Rhoads & Sons, J. E.

BERYLLIUM COPPER FOR MOLDS

Beryllium Corp. of Pa.

BLOWERS, PORTABLE ELECTRIC

(Dust, Dry Air, etc.)

Clements Mfg. Co.
Cappus Engineering Co.
Champion Blower & Forge Co.
Falstrom Co.
Ingersoll Rand Co.
Sturtevant Co., B. F
Tenney Engineering, Inc.

BOILERS

Babcock & Wilcox Co.
Eclipse Fuel Eng. Co.
Hendrick Mfg. Co.
Mears-Kane-Ofeldt, Inc.
Patterson Foundry & Machine Co.
Struthers-Wells Co.
Wickes Boiler Company

BUFFING AND POLISHING COMPOUNDS

Carborundum Co.
Griffiths & Co., Inc., F. K
Hanson-Van Winkle Munning Co.
Lea Mfg. Co.
Lignum Chemical Works, The
Lupomatic Tumbling Machine Co., Inc.
Matchless Metal Polish Co.
McAleer Mfg. Co.
Production Machine Co.
Rogers, Wm. R.
Siebert, Rudolph R.
United Laboratories, Inc.
U. S. Chemical Co.
Universal Tumbling Compounds

BUFFS

Codman Co., F. L. & J. C.
Divine Bros. Co.
Hanson-Van Winkle Munning Co.
Lea Mfg. Co.
MacFarland Mfg. Co., Inc.
McAleer Mfg. Co.
Production Machine Co.
Superior Engineering Co.

COMPRESSORS, AIR

Abbé Engineering Co.
Aldrich Pump Co.
American Steam Pump Co.
Chicago Pneumatic Machinery Co.
Curtis Pneumatic Machinery Co.
De Laval Steam Turbine Co.
Gardner-Denver Co.
Ingersoll Rand Co.
Loomis Co., Evarts G.
Martin, Frank M.
Nash Engineering Co.
Pennsylvania Pump & Compressor Co.
Sullivan Machinery Co.
Worthington Pump & Machinery Corp.

CONDENSERS

Aldrich Pump Co.
Hendrick Mfg. Co.
Ingersoll Rand Co.
Loomis Co., Evarts G.
Patterson Foundry & Machine Co.
Pennsylvania Pump & Compressor Co.
Stokes Machine Co., F. J.
Struthers-Wells Corp.

CONTAINERS, CORRUGATED SHIPPING

Container Corp. of America
Gair Co. Inc., Robert
Gaylord Container Corp.
Hinde & Dauch Paper Co.
Inland Container Corp.

CONTROLLERS, PRESSURE

Atlas Valve Co.
Bristol Co.
Brown Instrument Co.
Cambridge Instrument Co., Inc.
Cash Co., A. W.
Foxboro Co.
French Oil Mill Machinery Co.
Hydraulic Press Mfg. Co., The
Hydro-Powers Systems, Inc.
Industrial Instrument Co.
Keckley Co., O. C.
Loomis Co., Evarts G.
Minneapolis Honeywell Regulator Co.
Powers Regulator Co., The
Standard Machinery Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Tenney Engineering, Inc.

CONTROLLERS, TEMPERATURE

Atlas Valve Co.
Bristol Company
Brown Instrument Co.
Cambridge Instrument Co., Inc.
Foxboro Company
Illinois Testing Laboratories, Inc.
Industrial Instrument Co.
Keckley Co., O. C.
Leeds & Northrup Co.
Loomis Co., Evarts G.
Martin, Frank M.
Minneapolis Honeywell Regulator Co.
Powers Regulator Co.
Standard Machinery Co.
Tagliabue Mfg. Co.
Taylor Instrument Companies
Tenney Engineering, Inc.
Thwing-Albert Instrument Co.
Vickers, Inc.

DUST COLLECTORS

American Air Filter Co.
Baker Perkins, Inc.
Baldor Electric Co.
Covel Mfg. Co.
Dracco Corp.
Falstrom Co.
Gruendler Crusher & Pulverizer Co.
Hammond Machinery Builders, Inc.
Kirk & Blum Mfg. Co.
Martin, Frank M.
Pangborn Corp.
Raymond Pulverizer Div., Combustion Engineering Co., Inc.
Sprout, Waldron & Co.
Wolf Co., The

FASTENING DEVICES

Continental Screw Co.
Corbin Screw Corp.
Holo-Krome Screw Corp.
Parker-Kalon Corp.
Phillips Cooperative Group:
American Screw Co.
Continental Screw Co.
Corbin Screw Corp.
Lamson & Sessions Co.
National Screw & Mfg. Co.
Parker-Kalon Corp.
Pheoll Mfg. Co.
Russell, Burdsall & Ward Bolt & Nut Co.
Scovill Mfg. Co.
Shakeproof Lock Washer Co.
Publix Metal Goods Corp.
Sterling Bolt Co.
Tinnerman Products, Inc.

GAGES

Baldwin-Southwark Div., Baldwin Locomotive Works
Bristol Co.
Cambridge Instrument Co., Inc.
Consolidated Ashcroft Hancock Co.
Elmes Engineering Works, Chas. F.
Foxboro Company
French Oil Mill Machinery Co.
Hydraulic Press Mfg. Co., The
Index Machinery Corp.
Indicating Calipers Corp.
Industrial Instrument Co.
Jerguson Gage & Valve Co.
Loomis Co., Evarts G.
Robertson Co., Inc., John
U. S. Gauge Co.
Vickers, Inc.
Watson-Stillman Co.
Wood Co., R. D.

Addresses of companies listed appear on pages 470–474

HEATING EQUIPMENT

Baker Perkins, Inc.
Despatch Oven Co.
Industrial Heater Co.
Ross Engineering Corp., J. O.
Royle & Sons, John

HOSE AND TUBING

(Flexible Metal)

American Brass Co., American Metal Hose Branch
Birdsboro Steel Foundry & Machine Co.
Chicago Metal Hose Corp.
Eclipse Aviation Corp.
Packless Metal Products Corp.
Pennsylvania Flexible Metallic Tubing Co.
Seamlex Co., Inc.
Wood Co., R. D.

HYDRAULIC VALVES AND FITTINGS

Adamson Machine Co., The
Albert & Son, L.
Aldrich Pump Co.
Atlas Valve Co.
Baldwin-Southwark Div., Baldwin Locomotive Works
Barnes Corp., John S.
Birdsboro Steel Foundry & Machine Co.
Bliss Co., E. W.
Burroughs Engineering Co.
Carver, Fred S.
Cash Co., A. W.
Chambersburg Engineering Co.
Crane Co.
Denison Engineering Co., The
Dunning & Boschert Press Co.
Elmes Engineering Works, Charles F.
French Oil Mill Machinery Co.
Hannifin Mfg. Co.
Hydraulic Press Mfg. Co.
Hydro-Powers Systems, Inc.
Jerguson Valve & Gage Co.
Keckley Co., O. C.
Logemann Brothers Co.
Loomis Co., Evarts G.
Racine Tool & Machine Co.
Robertson Co., Inc., John
Vickers, Inc.
Walworth Co.
Watson-Stillman Co.
Wood Co., R. D.
Yarnall-Waring Co.

INSERTS, METAL INLAYS AND METAL FINDINGS

Aluminum Co. of America
Brass Goods Mfg. Co.
Chase Brass & Copper Co.
Etched Products Corp.
Grammes & Sons, Inc., L. F.
Lamson & Sessions Co., The
Parker-Kalon Corp.
Plastic Inlays, Inc. (Chilton Process)
Precision Shapes, Inc.
Probar Corp.
Publix Metal Goods Corp.
Scovill Mfg. Co.
Stanley Works
Steinen Mfg. Co., William
Whitney Mfg. Co.
Wrought Washer Mfg. Co.

JOINTS, FLEXIBLE—BALL, PIPE, SWIVEL AND REVOLVING

Adamson Machine Co., The
Atlas Valve Co.
Barco Mfg. Co.
Chicago Metal Hose Corp.
Chiksan Tool Co.
Elmes Engineering Works, Chas. F.
Flexo Supply Co., Inc.
French Oil Mill Machinery Co.
Grinnell Co.
Hydraulic Press Mfg. Co.
Loomis Co., Evarts G.
Philadelphia Gear Works
Publix Metal Goods Corp.
Seamlex Co., Inc.
Syntron Co.
Taylor Forge & Pipe Works
U. S. Pipe & Foundry Co.
Wood Co., R. D.

KETTLES, RESIN

Alloy Fabricators, Inc.
Baker Perkins Inc.
Blaw-Knox Co.
Buffalo Foundry & Machine Works
Devine Mfg. Co., J. P.
Glascote Co.
Groen Mfg. Co.
Hendrick Mfg. Co.
Lee Metal Products Co.
Liberty Coppersmithing Co.
Loomis Co., Evarts G.
Martin, Frank M.
Oat & Son, Jos.
Orange Roller Bearing Co.
Patterson Foundry & Machine Co.
Read Machinery Co., Inc.
Sowers Mfg. Co.
Stokes Machine Co., F. J.
Struthers-Wells Co.
Van Alst Metalsmiths Co.

MACHINES—DRILLING, MILLING, TAPPING, SAWING, FILING, JIG BORING, SLICING, SANDERS, LATHES, TOOLS, ETC.

Atlas Press Co.
Atlas Tool Works
Augat Machine & Tool Co., A. A.
Avery Drilling Machine Co.
Black & Decker Mfg. Co., The
Bodine Corp.
Browne & Sharpe Mfg. Co.
Bullard Co.
Cavagnaro, John J.
Champion Blower & Forge Co.
Cincinnati Lathe & Tool Co.
Cleveland Duplex Machinery Co.
Cleveland Planer Co.
Colton Co., Arthur
Continental Machines, Inc.
Dayton Punch & Die Works
Delta Mfg. Co.
Ekstrom Carlson & Co.
Engineering Laboratories, Inc.
Gisholt Machine Co.
Gorton Machine Co., George
Grimes & Harris, Inc.
Hardinge Brothers, Inc.
Harvey Machine Co.
Henry & Wright Mfg. Co.
Index Machinery Corp.
Ingersoll Milling Machine Co.
International Machine Tool Co., Inc.
Kearney & Trecker Corp.
King Machine Tool Co.
Kingsbury Machine Tool Corp.
Leominster Tool Co., Inc.
Lucas Machine Tool Co.
Lucas & Son, J. L.
Marburg Bros, Inc.
Morse Twist Drill & Machine Co.
National Automatic Tool Co.
National Machine Tool Co.
Oliver Instrument Co.
Porter-Cable Machine Co.
Power King Tool Corp.
Pratt & Whitney Co.
Preis Engraving Machine Co., H. P.
Production Machine Co.
Racine Tool & Machine Co.
Reed-Prentice Corp.
Rockford Machine Tool Co.
Root Co., B. M.
Ryerson & Son, Jos. T.
South Bend Lathe Works
Standard Tool Co.
Walker-Turner Co., Inc.
White Dental Mfg. Co., S. S., Ind. Div.
Whitney & Son, Inc., Baxter D.

MACHINES, BUFFING AND POLISHING

American Rotary Tools Co., Inc.
Baldor Electric Co.
Black & Decker Mfg. Co., The
Bridgeport Safety Emery Wheel Co., Inc.
Champion Blower & Forge Co.
Chicago Wheel & Mfg. Co.
Cincinnati Electrical Tool Co.
Delta Mfg. Co.
Ekstrom Carlson & Co.
Grimes & Harris. Inc.
Hammond Machine Builders, Inc.
Hanson-Van Winkle-Munning Co.
Haskins Co., R. G.
Ingersoll Rand Co.
Jackson Buff Corp.
Lea Mfg. Co.
Lupomatic Tumbling Machine Co., Inc.
Production Machine Co.
U. S. Electrical Tool Co.
Van Dorn Elec. Tool Co.
Walker Turner Co., Inc.
White Dental Mfg. Co., S. S., Ind. Div.

MACHINES, CUT-OFF

Albert & Son, L.
Bridgeport Safety Emery Wheel Co., Inc.
Cincinnati Electrical Tool Co.
Delta Mfg. Co.
Engineering Laboratories, Inc.
Grimes & Harris, Inc.
Lea Mfg. Co.
Lupomatic Tumbling Machine Co., Inc.
Power King Tool Co.
Racine Tool & Machine Co.
Root Co., B. M.
Standard Tool Co.
Walker-Turner Co., Inc.

MACHINES, DIE CASTING

Ekstrom Carlson & Co.
French Oil Mill Machinery Co.
Index Machinery Corp.
Kux-Lohner Machine Co.
Lester Engineering Co.
Reed-Prentice Corp.
Standard Tool Co.

MACHINES, DIE-DUPLICATING

Elmes Engineering Works, Chas. F.
Gorton Machine Co., George
Kearney & Trecker Corp.
Pratt and Whitney, Div. Niles-Beaumont Pond Co.
Preis Engraving Machine Co., H. P.
Reed-Prentice Corp.

MACHINES, DIE SINKING

Ekstrom Carlson & Co.
Kearney & Trecker Corp.

MACHINES, ENGRAVING

Ackerman-Gould Corp.
American Rotary Tools Co., Inc.
Auto Engraver Co.
Gorton Machine Co., George
Markem Machine Co.
Peerless Roll Leaf Co., Inc.
Preis Engraving Machine Co., H. P.
Reed-Prentice Corp.
Royle & Sons, John

MACHINES, EXTRUDING

(Screw-type)

National Rubber Machinery Co.
Royle & Sons, John

MACHINES, GRINDING

(Abrasive)

Abbé Engineering Co.
Abbé, Inc., Paul O.
Albert & Son, L.
Allis-Chalmers Mfg. Co.
Baker Perkins Inc.
Baldor Electric Co.
Bridgeport Safety Emery Wheel Co., Inc.

Champion Blower & Forge Co.
Chicago Wheel & Mfg. Co.
Cincinnati Electrical Tool Co.
Cincinnati Lathe & Tool Co.
Colton Co., Arthur
Delta Mfg. Co.
De Mattia Machine & Tool Co.
Engineering Laboratories, Inc.
Hammond Machinery Builders, Inc.
Ingersoll Rand Co.
Leominster Tool Co., Inc.
Martin, Frank M.
Mead & Co.
Norton Co.
Porter-Cable Machine Co.
Power King Tool Corp.
Production Machine Co.
Pulverizing Machinery Co.
White Dental Mfg. Co., S. S., Ind. Div.
Wolf Co., The

MACHINES, GRINDING
(Granulating)

Allis-Chalmers Mfg. Co.
Baker Perkins Inc.
Ball & Jewell
Colton Co., Arthur
De Mattia Machine & Tool Co.
Gruendler Crusher & Pulverizer Co.
Ingersoll Rand Co.
Leominster Tool Co., Inc.
Martin, Frank M.
Mead & Co.
Preis Engraving Machine Co., H. P.
Pulverizing Machinery Co.
Raymond Pulverizer Div., Combustion Engineering Co., Inc.
Robinson Mfg. Co.
Sprout, Waldron & Co.
Stokes Machine Co., F. J.

MACHINES, MIXING, KNEADING AND SIFTING

Abbé Engineering Co.
Abbé, Inc., Paul O.
Albert & Son, L.
Baker Perkins Inc.
Cavagnaro, John J.
Colton Co., Arthur
Drakenfeld & Co., Inc.
Elmes Engineering Works, Charles F.
Gruendler Crusher & Pulverizer Co.
Hendrick Mfg. Co.
Loomis Co., Evarts G.
Martin, Frank M.
Patterson Foundry & Machine Co.
Read Machinery Co., Inc.
Robinson Mfg. Co.
Sprout, Waldron & Co.
Stokes Machine Co., F. J.
Struthers-Wells Corp.
Thropp & Sons, Co., Wm. R.
Wolf Co., The

MACHINES, PROFILING

Cincinnati Lathe & Tool Co.
Gorton Machine Co., George
Kearney & Trecker Corp.
Preis Engraving Machine Co., H. P.
Reed-Prentice Corp.

MACHINES, PULVERIZING

Abbé Engineering Co.
Abbé, Inc., Paul O.
Albert & Son, L.
Baker Perkins Inc.
Gruendler Crusher & Pulverizer Co.
Jeffrey Mfg. Co.
Krehbiel Co., Inc., J. J.
Loomis Co., Evarts G.
Machinery Builders, Inc.
Martin, Frank M.
Mead & Co.
Mitts & Merrill
Patterson Foundry & Machine Co.
Pulverizing Machinery Co.
Raymond Pulverizer Div., Combustion Engineering Co., Inc.
Robinson Mfg. Co.
Sprout, Waldron & Co.
Stokes Machine Co., F. J.
Thropp & Sons Co., Wm. R.

MACHINES, SLUGGING

Colton Co., Arthur
Kux-Lohner Machine Co.
Stokes Machine Co., F. J.

MACHINES, TUMBLING

Hanson-Van Winkle-Munning Co.
Lea Mfg. Co.
Lupomatic Tumbling Machine Co., Inc.
Martin, Frank M.
McCormick Co., J. S.
Royersford Foundry & Machine Co., Inc.
Siebert, Rudolph R.
Sly Mfg. Co., W. W.
Whiting Corp.

MARKING DEVICES

Ackerman-Gould Corp.
Altair Machinery Corp.
Gorton Machine Co., George
Griffin, Campbell, Hayes, Walsh, Inc.
Markem Machine Co.
Matthews & Co., James H.
Pannier Bros. Stamp Co.
Parker Stamp Works
Peerless Roll Leaf Co., Inc.
Preis Engraving Machine Co., H. P.
Simplex Gold Stamping Press Co., Inc.

METAL FINDINGS AND INLAYS
(See Inserts, Metal Inlays)

MOLDS, CUSTOM (MAKERS OF)

Ability Mold & Die Works
Ace Tool Co.
American Molding Co.
Atlas Tool Works
Auburn Button Works, Inc.
Augat Machine & Tool Co., A. A.
Berry Tool and Machine Corp.
Beryllium Corp. of Pa.
Brockton Machine Co.
Brockton Tool Co.
Burroughs Engineering Co.
Chicago Die Mold Mfg. Co.
Consolidated Molded Products Corp.
Dayton Insulating Molding Co.
De Mattia Machine & Tool Co.
Deveau Machine Tool Co., C. O.
Die & Tool Co.
Doerfler, L.
Doyle Machine & Tool Co.
Eagle Tool and Machine Co.
Echlin Mfg. Co.
Eclipse Moulded Products Co.
Ekstrom Carlson & Co.
Engineering Specialties Corp.
Federal Tool Corp.
Fortney Mfg. Co.
Frank, Aug. C.
Freitag Mfg. Co., R. H.
Gits Molding Corp.
Gougler Machine Co., C. L.
Grimes & Harris, Inc.
Groetchen Tool Mfg. Co.
H. & W. Mold Co.
Haffling Co., E. V.
Harvey & Sons, Guy
Hedges Co., B. E.
Highland Mfg. Co.
Holmes Mfg. Co.
Industrial Molded Prods. Co.
Industrial Tool & Die Co.
Insulation Mfg. Co., Inc.
Johns Mfg. Co.
Kobzy Tool Co.
Krasberg and Sons Mfg. Co., R.
Krautter & Weber Tool Co.
Kuhn and Jacob Moulding and Tool Co.
Kurz-Kasch, Inc.
Leominster Tool Co.
Liberty Tool & Die Corp.
Liberty Tool & Gauge Works
Loux & Sons Mfg. Co., Jacob
Many, Julius
Manufacturers Tool and Die Corp.
Marmont Plastics, Inc.
Matthews & Co., James H.
Mechanical Die and Tool Co., Inc.
Mechanical Mold and Machine Co.
Mechanical Institute
Midland Die & Engraving Co.
Midwest Tool Co.
Modern Die & Mould Co.
Molded Insulation Co.
National Tool and Die Co.
New Jersey Engraving Co., Div. Sterling Plastics Co.
Newark Die Co.
Niedermayr Pattern and Machine Wks., Inc., Franz P.
Pannos Mfg. Co.
Parker Stamp Works
Peerless Mold & Machine Co.
Pfaff Tool and Die Co.
Pioneer Mold Co.
Reed-Prentice Corp.
Roberts Mfg. Co., Inc.
Royal Tool Co.
Schoder & Lombard Die and Stamping Co.
Schultz Boyar Co.
Service Tool and Die Co.
Sinko Tool and Mfg. Co.
Special Tool and Machine Co.
Square Tool and Die Co.
Standard Tool Co.
Stricker-Brunhuber Corp.
Summit Roberts Tool Co.
Taft-Pierce Mfg. Co.
Terkelsen Machine Co.
Tilp, Inc., J. G.
Tuck Co., A. J.
Tupper Co., Earl S.
Uptown Tool Works
W. and A. Tool and Die Works
Waterbury Button Co.
Webster Co., The

PACKINGS, LEATHER

Baldwin-Southward Div., Baldwin Locomotive Works
Elmes Engineering Works, Chas F.
Graton & Knight Mfg. Co.
Hydraulic Press Mfg. Co., The
Rhoads & Sons, J. E.
Robertson Co., Inc., John
Watson-Stillman Co.
Wood Co., R. D.

PLATING OF MOLDS, CHROMIUM AND NICKEL

American Nickeloid Corp.
Apollo Metal Works
Associated Attleboro Mfrs., Inc.
Burr Chromium Co., Inc.
Chromium Corp. of America
Industrial Plating & Finishing Co.
Martin, Frank M.
Sievering, Inc., Philip
Tuck Co., A. J.

PLATING OF PLASTICS
(With Metal)

Metaplast Corp.
Sievering, Inc., Philip
Special Chemicals Corp.
Universal Plating & Novelty Co.

POLISHING PRESS PLATES

Baldwin-Southwark Corp.
Burroughs Engineering Co.
Hawkridge Bros. Co
Loomis Co., Evarts G.
Martin, Frank M.
Sievering, Inc., Philip
Wood Co., R. D.

PREHEATING EQUIPMENT

Despatch Oven Co.
Falstrom Co.
Grimes & Harris, Inc.
Preheat Co.
Standard Tool Co.

PRESSES, ARBOR

American Broach & Machine Co.
Atlas Press Co.
Baldwin-Southwark Division, Baldwin Locomotive Works
Birdsboro Steel Foundry & Machine Co.
Chambersburg Engineering Co.
Champion Blower & Forge Co.
French Oil Mill Machinery Co.
Greenerd Arbor Press Co.
Hannifin Mfg. Co.
Hydraulic Press Mfg. Co., The
Logansport Machine Co.
Williams, White & Co.

PRESSES, AUTOMATIC COMPRESSION

Adamson Machine Co., The
Baldwin-Southwark Division, Baldwin Locomotive Works
Cropp Engineering Division
Dunning & Boschert Press Co.
Elmes Engineering Works, Charles F.
French Oil Mill Machinery Co.
Hydraulic Press Mfg. Co., The
Index Machinery Corp.
Lake Erie Engineering Corp.
Martin, Frank M.
Reed-Prentice Corp.
Standard Machinery Co.
Stokes Machine Co., F. J.
Terkelson Machine Co.
Watson-Stillman Co.

PRESSES, CAKING

Baldwin-Southwark Division, Baldwin Locomotive Works
Birdsboro Steel Foundry & Machine Co.
Burroughs Engineering Co.
Cavagnaro, John J.
Hannifin Mfg. Co.
Hydraulic Press Mfg. Co.
Loomis Co., Evarts G.
Martin, Frank M.
Robertson Co., Inc., John
Standard Machinery Co.
Stokes Machine Co., F. J.
Watson-Stillman Co.
Wood Co., R. D.

PRESSES, EMBOSSING

Ackerman-Gould Corp.
Adamson Machine Co., The
Albert & Son, L.
Altair Machinery Corp.
Baldwin-Southwark Division, Baldwin Locomotive Works
Beck Machine Co., Chas.
Birdsboro Steel Foundry & Machine Co.
Bliss Co., E. W.
Burroughs Engineering Co.
Carver, Fred S.
Cavagnaro, John J.
Chambersburg Engineering Co.
Dunning & Boschert Press Co.
Elmes Engineering Works, Chas. F.
Engineering Laboratories, Inc.
Farrel-Birmingham Co.
French Oil Mill Machinery Co.
Grimes & Harris, Inc.
Hydraulic Press Mfg. Co.
Lake Erie Engineering Corp.
Loomis Co., Evarts G.
Matthews & Co., James H.
Peerless Roll Leaf Co., Inc.
Robertson Co., Inc., John
Standard Machinery Co.
Standard Tool Co.
Stokes Machine Co., F. J.
Trand & Sons, Alex
Watson-Stillman Co.
Williams, White & Co.
Wood Co., R. D.

PRESSES, EXTRUDING

Albert & Son, L.
Aurelio Tanzi Eng. Co.
Baldwin-Southwark Division, Baldwin Locomotive Works
Birdsboro Steel Foundry & Machine Co.
Bliss Co., E. W.
Burroughs Engineering Corp.
Carver, Fred S.
Cavagnaro, John J.
Dunning & Boschert Press Co.
Elmes Engineering Works, Chas. F.
Farrel-Birmingham Co.
Farquhar Co., Ltd., A. B.
French Oil Mill Machinery Co.
Hydraulic Press Mfg. Co.
Index Machinery Corp.
Krehbiel Co., Inc., J. J.
Lake Erie Engineering Corp.
Loomis Co., Evarts G.
Martin, Frank M.
National Erie Corp.
Robertson Co., Inc., John
Royle & Sons, John
Watson-Stillman Co.

PRESSES, HOBBING

Baldwin-Southwark Division, Baldwin Locomotive Works
Birdsboro Steel Foundry & Machine Co.
Bliss Co., E. W.
Burroughs Engineering Co.
Elmes Engineering Works, Chas. F.
French Oil Mill Machinery Co.
Hydraulic Press Mfg. Co.
Lake Erie Engineering Corp.
Loomis Co., Evarts G.
Midland Die & Engraving Co.
Newark Die Co.
Robertson Co., Inc., John
Watson-Stillman Co.
Williams, White & Co.
Wood Co., R. D.

PRESSES, HYDRAULIC

(Compression)

Adamson Machine Co., The
Albert & Son, L.
Baldwin-Southwark Division, Baldwin Locomotive Works
Birdsboro Steel Foundry & Machine Co.
Bliss Co., E. W.
Burroughs Engineering Co.
Carver, Fred S.
Denison Engineering Co., The
Dunning & Boschert Press Co.
Elmes Engineering Works, Chas. F.
Emerman & Co., Louis E.
Farrel-Birmingham Co., Inc.
French Oil Mill Machinery Co.
Hannifin Mfg. Co.
Hydraulic Press Mfg. Co.
Index Machinery Corp.
Kux-Lohner Machine Co.
Lake Erie Engineering Corp.
Logemann Bros. Co.
Loomis Co., Evarts G.
Martin, Frank M.
National Erie Co.
Robertson Co., Inc., John
Spadone Machine Co., Inc.
Standard Machinery Co., The
Stokes Machine Co., F. J.
Terkelsen Machine Co.
Thropp & Sons Co., Wm. R.
Watson-Stillman Co.
Williams, White & Co.
Wood Co., R. D.

PRESSES, INJECTION MOLDING

Burroughs Engineering Co.
De Mattia Machine & Tool Co.
French Oil Mill Machinery Co.
Grotelite Co.
Hydraulic Press Mfg. Co.
Index Machinery Corp.
Krehbiel Co., Inc., J. J.
Kux-Lohner Machine Co.
Lester Engineering Co.
Loomis Co., Evarts G.
Reed-Prentice Corp.
Standard Tool Co.
Watson-Stillman Co.

PRESSES, INLAYING

Altair Machinery Corp.
Ams Machine Co., Max
Baldwin-Southwark Division, Baldwin Locomotive Works
Birdsboro Steel Foundry & Machine Co.
Bliss Co., E. W.
Cameron Can Machinery Co.
Carver, Fred S.
Grimes & Harris, Inc.
Hydraulic Press Mfg. Co.
Index Machinery Corp.
Niagara Machine & Tool Works
Peck-Stow & Wilcox Co.
Plastic Inlays, Inc.
Standard Tool Co.
Stokes Machine Co., F. J.

PRESSES, LABORATORY

Adamson Machine Co.
Albert & Son, L.
Aurelio Tanzi Eng. Co.
Baldwin Southwark Division, Baldwin Locomotive Works
Birdsboro Steel Foundry & Machine Co.
Burroughs Engineering Co.
Carver, Fred S.
Cavagnaro, John J.
Colton Co., Arthur
Eimer & Amend
Elmes Engineering Works, Chas. F.
Farquhar Co. Ltd., A. B.
Farrel-Birmingham Co.
French Oil Mill Machinery Co.
Hannifin Mfg. Co.
Hydraulic Press Mfg. Co.
Krehbiel Co., Inc., J. J.
Loomis Co., Evarts G.
Martin, Frank M.
Robertson Co. Inc., John
Standard Machinery Co.
Stokes Machine Co., F. J.
Terkelsen Machine Co.
Thropp & Sons Co., Wm. R.
Watson-Stillman Co.
White Dental Mfg. Co., S. S., Ind. Div.
Williams, White & Co.
Wood Co., R. D.

PRESSES, LAMINATING

Baldwin-Southwark Division, Baldwin Locomotive Works
Birdsboro Steel Foundry & Machine Co.
Dunning & Boschert Press Co.
Elmes Engineering Works, Charles F.
Farrel-Birmingham Co., Inc.
French Oil Mill Machinery Co.
Hydraulic Press Mfg. Co.
Lake Erie Engineering Co.
Watson-Stillman Co.
Williams, White & Co.
Wood Co., R. D.

PRESSES, PREFORMING

Colton Company, Arthur
Defiance Machine Works, Inc.
Hydraulic Press Mfg. Co.
Kux-Lohner Machine Co.
Standard Machinery Co.
Stokes Machine Co., F. J.

PRESSES, STAMPING

Ackerman-Gould Corp.
Altair Machinery Corp.
Baldwin Southwark Division, Baldwin Locomotive Works
Bliss Co., E. W.
Elmes Engineering Works, Chas. F.
French Oil Mill Machinery Co.
Griffin, Campbell, Hayes, Walsh, Inc.
Henry & Wright Mfg. Co.
Hydraulic Press Mfg. Co., The
Kingsley Gold Stamping Machine Co.
Lake Erie Engineering Corp.
Markem Machine Co.
Matthews & Co., James H.
Peerless Roll Leaf Co., Inc.
Robertson Co. Inc., John
Simplex Gold Stamping Press Co., Inc.
Williams, White & Co.

PRESSES, TOGGLE

Albert & Son, L.
Ams Machine Co., Max
Bliss Co., E. W.
Dunning & Boschert Press Co.
Engineering Laboratories, Inc.
French Oil Mill Machinery Co.
Grimes & Harris, Inc.
Index Machinery Corp.
Krehbiel Co., Inc., J. J.
Kux-Lohner Machine Co.
Logemann Bros. Co.
Niagara Machine & Tool Works
Standard Machinery Co.
Standard Tool Co.
Stokes Machine Co., F. J.
Terkelsen Machine Co.
Toledo Machine & Tool Co

PUMPS, HYDRAULIC

Albert & Son, L.
Aldrich Pump Co.
American Engineering Co.
American Steam Pump Co.
American Well Works
Baldwin Southwark Division, Baldwin Locomotive Works
Barnes Corp., John S.
Birdsboro Steel Foundry & Machine Co.
Browne & Sharpe Mfg. Co.
Burroughs Engineering Co.
Carbondale Machine Co.
Chambersburg Engineering Co.
Cropp Engineering Division
De Laval Steam Turbine Co.
Dunning & Boschert Press Co.
Elmes Engineering Works, Chas. F.
Erie Pump & Engine Works
Farquhar Co., Ltd., A. B.
French Oil Mill Machinery Co.
Hydraulic Engineering Works
Hydraulic Press Mfg. Co.
Ingersoll Rand Co.
Lake Erie Engineering Co.
Logemann Bros. Co.
Loomis Co., Evarts G.
Martin, Frank M.
Racine Tool & Machine Co.
Robertson Co., Inc., John
Thropp & Sons Co., Wm. R.
Union Steam Pump Co.
Vickers, Inc.
Watson-Stillman Co.
Worthington Pump & Machinery Corp.

PUMPS, VACUUM

Abbé Engineering Co.
Albert & Son, L.
Aldrich Pump Co.
Beach-Russ Co.
Cincinnati Lathe & Tool Co.
Ingersoll Rand Co.
Kinney Mfg. Co.
Lammert & Mann Co.
Loomis Co., Evarts G.
Martin, Frank M.
Nash Engineering Co.
National Scientific Corp.
Pennsylvania Pump & Compressor Co.
Stokes Machine Co., F. J.
Union Steam Pump Co.
Worthington Pump & Machinery Corp.

PYROMETERS

Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cambridge Instrument Co., Inc.
Engelhard, Inc., Chas.
Foxboro Co.
Hoskins Mfg. Co.
Illinois Testing Laboratories, Inc.
Index Machinery Corp.
Leeds & Northrup Co.
Loomis Co., Evarts G.
Minneapolis Honeywell Regulator Co.
Pyrometer Instrument Co.
Republic Flow Meters Co.
Russell Electric Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Companies
Thwing-Albert Instrument Co.
Wilson-Maeulen Pyrometer Co.

STEEL FOR HOBS

Achorn Steel Co.
Alleghany Ludlum Steel Corp.
Carpenter Steel Co.
Disston & Sons, Inc., Henry
Hawkridge Bros. Co.
Holliday & Co., W. J.
Jessop & Sons, Inc., Wm.
Matthews & Co., James H.
McDonald & Co., P. F.
Republic Steel Corp.
Ziv Steel and Wire Co.

STEEL FOR MOLDS

Achorn Steel Co.
Alleghany Ludlum Steel Corp.
American Rolling Mills
Carpenter Steel Co.
Crucible Steel Co. of America
Disston & Sons, Inc., Henry
Hawkridge Bros. Co.
Holliday & Co., W. J.
Jessop & Sons, Inc., Wm.
Latrobe Elec. Steel Co.
Ludlum Steel Co.
Matthews & Co., James H.
McDonald & Co., P. F.
Republic Steel Corp.
Vanadium Alloy Steel Co.
Ziv Steel and Wire Co.

TESTING APPARATUS

Adamson Machine Co., The
Baker Perkins, Inc.
Baldwin Southwark Division, Baldwin Locomotive Works
Brown Instrument Co.
Cambridge Instrument Co.
Falstrom Co.
Gisholt Machine Co.
Illinois Testing Laboratories, Inc.
Indicating Calipers Corp.
Martin, Frank M.
Olsen Testing Machine Co., Tinius
Read Machinery Co., Inc.
Scott Co., Henry L.
Shallcross Mfg. Co.
Tenney Engineering, Inc.
Testing Machines Co.
Thropp & Sons Co., Wm. R.
Thwing-Albert Instrument Co.

TIMING DEVICES

Bristol Co.
Cramer Co., Inc., R. W.
French Oil Mill Machinery Co.
Industrial Instrument Co.
Leeds & Northrup Co.
Partlow Corp.
Standard Machinery Co.

MOLDERS, FABRICATORS, DESIGNERS

EDUCATIONAL INSTITUTIONS, FOREIGN AND OTHER INCIDENTAL SERVICES

COLD MOLDERS

American Insulator Corp.
Cutler-Hammer, Inc.
Garfield Mfg. Co.
General Electric Co., Plastics Dept.
Haveg Corp.
International Molded Plastics, Inc.
Keasbey & Mattison
Plastic Molding Corp.

CONSULTING AND TESTING

Alexander, Jerome, 50 E. 41 St., N. Y. C.
Bacon, Frederick S., 192 Pleasant St., Watertown, Mass.
DeBell, John M., 20 Edgewood Ave., Longmeadow, Mass.
Electrical Testing Laboratories, 79th St. & East End Ave., New York, N. Y.
Ellis Laboratories, Inc., 98 Greenwood Ave., Montclair, N. J.
Esselen, Inc., Gustavus J., 857 Boylston St., Boston, Mass.
Grosvenor, Wm. M., 50 E. 41 St., N. Y. C.
Industrial Research and Engineering Co., 7325 Penn Ave., Pittsburgh, Pa.
Little, Inc., A. D., 30 Charles River Road, Cambridge, Mass.
New York Testing Laboratories, 80 Washington St., New York, N. Y.
Norton, Arthur J., Box 1745, Portland, Me.
Orthmann Laboratories Inc., The, Milwaukee, Wis.
Pelerano, S.,1918 71 St., Brooklyn, N. Y.
Pittsburgh Testing Laboratory, Stevenson St. at Locust, Pittsburgh, Pa.
Pollak, Dr. Fredr., 114 E. 32 St., N. Y. C.
Plastics Industries Technical Institute, 186 So. Alvarado St., Los Angeles, Calif.
Scogland, Charles A., 215 W. Navarre St., South Bend, Ind.
Simonds, J. Earl, 58 Beauvoir Pl., Summit, N. J.
Snell, F. D., 305 Washington St., Brooklyn, N. Y.
Stringfield, R. B., 229 S. Normandy Ave., Los Angeles, Cal.
Technichemical Laboratories, 24 Stone St., N. Y. C.
United States Testing Co., Inc., 1415 Park Ave., Hoboken, N. J.
Wacker, George W., 4616 Reading Rd., Cincinnati, O.
Weiss & Downs, Inc., 50 East 41st St., N. Y. C.
Wilmington Testing and Research Laboratories, 1002 West St., Wilmington, Del.

CUSTOM MOLDERS, COMPRESSION

Accurate Molding Corp.
Ackerman Rubber & Plastic Molding Co.
Advance Molding Corp.
Anfinsen Plastic Molding Co.
Alden Products Co.
Allied Plastics Corp.
American Hard Rubber Co.
American Insulator Corp.
American Molding Co.

Addresses of companies listed appear on pages 470–474

Amos Molded Plastics Div., Amos-Thompson Corp.
Anchor Cap & Closure Corp.
Armstrong Cork Co., Glass & Closure Division
Associated Attleboro Mfrs., Inc.
Atlantic Plastics
Auburn Button Works, Inc.
Automatic Molded Prods. Co.
Ballard Plastics Corp.
Barber-Coleman Co.
Bay Mfg. Co., The
Bay State Molding Co.
Beaman Molded Products Co.
Boonton Molding Co.
Breeze Corporations, Inc.
Bridgeport Molded Products, Inc.
Brill-Monfort Co., Inc.
Bryant Electric Co., The
Butterfield, Inc., T. F.
Button Corp. of America
California Plastic Molding Co.
Central Die Casting Co.
Chicago Die Mold Mfg. Co.
Chicago Molded Products Corp.
Cincinnati Molding Co.
Cleveland Plastics, Inc.
Climax Mfg. & Molding Corp.
Colt's Patent Fire Arms Mfg. Co.
Compo-site, Inc.
Connecticut Hard Rubber Co., The
Consolidated Molded Products Corp.
Cutler-Hammer, Inc.
Davies Molding Co., Harry
Dayton Insulating Molding Co.
Diemolding Corp.
Eagle Plastic Corp.
Eclipse Moulded Products Co.
Economy Fuse & Mfg. Co.
Erie Resistor Corp.
Eureka Button Co.
Federal Tool Corp.
Firestone Rubber & Latex Products Co.
Franklin Plastic & Die Casting, Div. Baldwin Laboratories, Inc.
Garfield Mfg. Co.
Gemloid Corp.
General Electric Co., Plastics Dept.
General Industries Co.
General Insulate Co., Inc.
General Molding Co.
General Products Corp.
Gibbs Mfg.
Gillum Plastic Molding, Jimmie
Globe Tool & Molded Prod. Co.
Grigoleit Co.
Gulliksen Mfg. Co., W. M.
Hahn Plastic & Die Cast Corp.
Hurst, Inc.
Hyde, A. L.
Imperial Molded Products Corp.
Industrial Molded Prods. Co.
Ingwersen, Inc.
Inland Mfg. Div., General Motors Corp.
Insel Co., The
Insulation Mfg. Co., Inc.
Insulation Prods. Co.
International Molded Plastics, Inc.
Jamison, H.
Keasbey & Mattison
Keeler Brass Co.
Kellogg Switchboard & Supply Co.
Kenilworth Button Mfg. Co.
Keystone Specialty Co.
Kilgore Mfg. Co., The
Kuhn & Jacob Moulding & Tool Co.
Kurz-Kasch, Inc.
Lanfare Molded Products
Leviton Mfg. Co.
Mack Molding Co., Inc.
Marmont Plastics, Inc.
Martindell Molding Co.
Meissner Mfg. Co.
Michigan Molded Plastics, Inc.
Mico, Inc.
Midwest Molding & Mfg. Co.
Modern Plastics Corp.
Molded Insulation Co.
Molded Plastics, Inc.
Molded Products Co.
Molded Products Co., Chicago
Molding Corp. of America
National Lock Co.
National Organ Supply Co.
National Plastics, Inc.
New Products Corp.
Niagara Insul-Bake Specialty Co., Inc.
Norris Plastics Co.
Northern Industrial Chemical Co.
Northwest Plastics, Inc.
Norton Laboratories, Inc.
Otis Mfg. Co.
O'Shei, B. F.
Owens-Illinois Glass Co., Closure Div.
Paragon Molding Co.
Patent Button Co. of Tenn., Inc.
Paulis, Inc., H.
Peerless Molded Plastics, Inc.
Phoenix Metal Corp.
Pittsburgh Plastics Co., Inc.
Place Co., Roland P.
Plano Molding Co.
Plastic Jewelry, Inc.
Plastic Molded Arts, Inc.
Plastic Molding Corp.
Plastic Moldings Corp.
Plastic Parts Co.
Plastic Products, Inc.
Plastic-Ware, Inc.
Plastics, Inc.
Plastics, Inc.
Plastik, Inc.
Poinsettia, Inc.
Quintard & McIlhiney
Rathbun Molding Corp.
Recto Molded Products, Inc.
Reinhold Co., F. E.
Remler Co., Ltd.
Reynolds Spring Co., Molded Plastics Div.
R. I. Moulding Works
Richardson Company
Royal Molding Co.
Salz Bros., Inc.
Scott Mfg. Co., Inc.
Shaw Insulator Co.
Sheller Mfg. Co.
Siemon Company
Sinko Tool & Mfg. Co.
Smith Molding Co., Frank B.
Specialty Insulation Mfg. Co.
Standard Cap & Molding Co.
Standard Plastics Co.
Sterling Plastic Co.
Stokes Rubber Co., Jos.
Synthetic Moulded Products, Inc.
Tech-Art Plastics Co.
Terkelsen Machine Co.
Tupper Co., Earl S.
Union Insulating Co.
United Comb & Novelty Co.
U. S. Plastic Corp.
Universal Plastics Corp.
Valley Molding Co.
Van Norman Molding Co.
Victor Mfg. & Gasket Co.
Victor Metal Prods. Corp.
Victory Molding Co.
Vichek Tool Co., The, Plastics Div.
Voges Mfg. Co.
Vulcanized Rubber Co.
Ward Plastic & Rubber Co.
Warren Plastics Corp.
Waterbury Button Co.
Watertown Mfg. Co.
Wheeling Stamping Co.
White Dental Mfg. Co., S. S., Ind. Div.
Windman Bros.
Woodruff Co., The
Worcester Moulded Plastics Co.
Zenith Plastics, Inc.
Ziwel Plastics Corp.

CUSTOM MOLDERS, INJECTION

Advance Molding Corp.
Allied Plastics Corp.
American Hard Rubber Co.
American Insulator Corp.
American Molded Products Co.
American Molding Co.
American Phenolic Corp.
Amos Molded Plastics Div., Amos-Thompson Corp.
Anfinsen Plastic Molding Co.
Armstrong Cork Co., Glass & Closure Division
Athol Comb Co.
Atlantic Plastics
Auburn Button Works, Inc.
Bachmann Bros., Inc.
Ballard Plastics Corp.
Bay Mfg. Co.
Belmont Molded Plastics, Inc.
Berkander, Geo. F.
Boonton Molding Co.
Bryant Electric Co., The
Bridgeport Molded Products, Inc.
Butterfield, Inc., T. F.
Button Corp. of America
Caldwell Products, Inc.
Cardinal Corp.
Chicago Molded Products Corp.
Claremould Plastics Corp.
Colt's Patent Fire Arms Mfg. Co.
Columbia Protektosite Co., Inc.
Columbus Plastic Products, Inc.
Commonwealth Plastics Co.
Connecticut Plastic Products Co.
Consolidated Molded Products Corp.
Cruver Mfg. Co.
Dayton Insulating Molding Co.
Detroit Macoid Co.
Diemolding Corp.
Emeloid Co.
Erie Plastics Co.
Erie Resistor Corp.
Firestone Rubber & Latex Products Co.
Foster-Grant Co., Inc.
Franklin Plastic & Die Casting, Div. Baldwin Laboratories, Inc.
Gemloid Corp.
General Electric Co., Plastics Dept.
General Industries Co.
Gillum Plastic Molding, Jimmie
Gits Molding Corp.
Hahn Plastic Die Cast Corp.
Hurst, Inc.
Hyde, A. L.
Inland Mfg. Div., General Motors Corp.
Injection Molding Co., The
Insel Co., The
Jamison, H.
Keeler Brass Co.
Keolyn Plastics Co.
Kilgore Mfg. Co., The
Kingman Company, E. B.
Lapin Products, Inc.
Mack Molding Co.
Mason Co., Inc., Thomas
Martindell Molding Co.
Merrigan Plastic Co.
Metal Specialty Co.
Michigan Molded Plastics, Inc.
Mills Corp., Elmer E.
Minnesota Plastic Corp.
Modern Plastic Co.
Modern Plastics Corp.
Molded Insulation Co.
Molded Plastics, Inc.
National Lock Co.
National Organ Supply Co.
National Plastics, Inc.
Norris Plastics Co.
Northern Industrial Chemical Co.
Norton Laboratories, Inc.
Ohio Plastics Co.
Paulis, Inc., H.
Peerless Molded Plastics, Inc.
Plano Molding Co.
Plastic Jewelry, Inc.
Plastic Molded Arts, Inc.
Plastic Molding Corp.
Plastic Products, Inc.
Plastics, Inc.
Plastik, Inc.
Pyro Plastics Co.
Recto Molded Products, Inc.

Remler Co., Ltd.
Reynolds Spring Co., Molded Plastic Div.
R. I. Moulding Works
Richardson Co.
St. Louis Plastic Moulding Co.
Salz Bros, Inc.
Shaw Insulator Co.
Shepherd Son & Co., J. H.
Sinko Tool & Mfg. Co.
Sobenite, Inc.
Standard Plastics Co.
Sterling Injection Molding Inc.
Sterling Plastics Co.
Stokes Rubber Co., Jos.
Superior Plastic Co.
Tech-Art Plastics, Inc.
Thermo-Plastics, Division, Standard Products Co.
Tilton-Cook Co.
Tupper Co., Earl S.
United Comb & Novelty Co.
U. S. Plastic Corp.
Universal Plastics Corp.
Victory Molding Co.
Vlchek Tool Co., The, Plastics Div.
Ward Plastic & Rubber Co
Warren Plastics Corp.
Waterbury Button Co.
Watertown Mfg. Co., The
White Dental Mfg. Co., S. S., Ind. Div.
Worcester Moulded Plastics Co.
Ziwel Plastics Corp.

DECORATION, APPLIED

(Printing, Stamping, Engraving, Inlays, Etc.)

Altair Machinery Corp.
Aument, H. Chester
Austin Co., The O.
Creative Displays
Gemloid Corp.
Griffin, Campbell, Hayes, Walsh, Inc.
Kingsley Gold Stamping Machine Co.
Markem Machine Co.
Morgan Lithograph Co.
Palm Fechteler & Co.
Peerless Roll Leaf Co., Inc.
Plastic Inlays, Inc.
Plastiglas Printing, Inc.
Plastiograph Co.
Probar Corp.
Quick Point Pencil Co.
Rogan Bros.
Scott & Doyle Co.
Transparent Printing Corp.

DESIGNERS, INDUSTRIAL

Ackerman, Jay, Warren, Conn.
Adams, Wilbur Henry, 2341 Carnegie Ave., Cleveland, Ohio.
Adler, S. E.; Modern Industrial Designers, 4544 N. Hazel Ave., Chicago, Ill.
Alcott, Thoner & Marsh, 271 East St., Islington, Mass.—833 Park Sq. Bldg., Boston, Mass.
Arens, Egmont, 480 Lexington Ave., N.Y.C.
Aronson, Joseph, 215 East 58 St., N. Y. C.
Bach, Alfons, 101 Park Ave., N. Y. C.
Bach, Oscar, 305 East 46 St., N. Y. C.
Barnes & Reinecke, 664 No. Michigan Ave., Chicago, Ill.
Bel Geddes, Norman, 50 Rockefeller Plaza, N. Y. C.
Bernhard, Lucian, 120 East 86 St., N. Y. C.
Bernstein, Arthur, 215 W. 91 St., N. Y. C.
Blow, George; De Vaulchier, Blow and Wilmet, 51 East 42 St., N. Y. C.
Brown, E. Norris, 15 Bradford Pl., Brockton, Mass.
Bry, Paul, 25 W. 54 St., N. Y. C.
Budlong, Inc., Robert D., 333 N. Michigan Ave., Chicago, Ill.
Bureau, Achille G., 374 Burns St., Forest Hills, N. Y.
California Plastic Products Co., 1800 So. Point View, Los Angeles, Calif.
Carpenter, Natalie, 562 W. 113 St., N. Y. C.
Casoyd, Sydney, 40 East 48 St., N. Y. C.
Cheron, Pierre, 65 Locust, Stratford, Conn.
Conant, Roger, 123 East 53 St., N. Y. C.
Covington-Burwick, 206 Oak Knoll, Mankato, Minn.
Creative Displays, 614 N. Carpenter St., Chicago, Ill.
Cruze, Charles, 2008 W. 7 St. & Westlake Bldg., Los Angeles, Calif.
D'Addario, Thomas, 11 W. 42 St., N. Y. C.
Daly, Grover J., 545 Vernon, Glencoe, Ill.
Designers for Industry, Inc., Merchandise Mart, Chi., Ill.; Terminal Tower, Cleveland, O.; 630 5th Ave., N. Y. C.
Deskey, Donald, 630 Fifth Ave., N. Y. C.
De Vaulchier, Blow and Wilmet, 51 East 42 St., N. Y. C.
De Vries, Herman, 49 W. 45 St., N. Y. C.
Dreyfuss, Henry, 501 Madison, N. Y. C.
Dryden, Helen, 25 Fifth Ave., N. Y. C.
Dulany, Helen Hughes, 936 Lake Shore Drive, Chicago, Ill.
Dunne, Liam, 412 East 52 St., N. Y. C.
Ehlert, Harold H., 730 Whitmore Rd., Detroit, Mich.
Eppenstein & Associates, Jos. F., 35 E. Wacker Drive, Chicago, Ill.
Erwin, Hobe G., 15 East 57 St., N. Y. C.
Faber, Guy S., 222 W. Adams St., Chicago, Ill.
Farr, Fred, 311 Prospect Ave., Mamaroneck, N. Y.
Federico, Jos. B., Portage Rd., Niagara Falls, N. Y.
Flamm, Alexander, 211 State St., Bridgeport, Conn.
French, Carroll, South Mountain Road, New York City, N. Y.
Gaba, Lester, 347 Fifth Ave., N. Y. C.
Gates, John M., 1 East 53 St., N. Y. C.
Gerth, Ruth K., 104 East 40 St., N. Y. C.
Gerth, William, 1625 Second Ave., N. Y. C.
Gilbert Felix, 145 East 53 St., N. Y. C.
Gruen, Robert, 30 East 55 St., N. Y. C.
Guild, Lurelle, 522 Fifth Ave., N. Y. C.
Hall, Frances Cushing, 604 Tompkins Ave., Mamaroneck, N. Y.
Hamill, Virginia, 6 East 45 St., N. Y. C.
Hart, James M., 1412 Seward Ave., Detroit, Mich.
Heller, Inc., Robert, 50 Rockefeller Plaza, N. Y. C.
Hess, Theodore, Palatine, Ill.
Hodges, Guy W., 10 East 40 St., N. Y. C.
Hoopes, Cunningham & McKinney, 12 S. 12 St., Phila., Pa.
Hornung, Clarence P., 23 W. 47, N. Y. C.
Jackson, Edwin, 175 East 60 St., N. Y. C.
Jeannette Display Studio, 1718 Navarre Rd., S. W., Canton, Ohio
Jensen, Gustav, 16 E. 48 St., N. Y. C.
Jiranek, Leo, 30 Rockefeller Plaza, N. Y. C.
Johnson Associates, Gerald, 280 Madison Ave., N. Y. C.
Johnson & Zaiser, 27 West 57 St., N. Y. C.
Keirstead, E. Warner, 74 Stewart Ave., Mansfield, Ohio.
Ketcham, Inc., Howard, 607 Fifth Ave., N. Y. C.
Kiesler, Frederic, 56 Seventh Ave., N. Y. C.
Kogan, Belle, 362 Fifth Ave., N. Y. C.
Korda Graphics, 2 West 46 St., N. Y. C.
Lescaze, William, 211 E. 48 St., N. Y. C.
Lietzke Designers, 1023 East Grand River, East Lansing, Mich.
Linder, Laura Lee, Pittsfield, Mass.
Little, John, 101 Park Ave., N. Y. C.
Loewy, Raymond, 580 Fifth Ave., N. Y. C.
Lux, Eugene, 44 W. 56 St., N. Y. C.
MacAlister, Paul, 30 Rockefeller Plaza, N. Y. C.
Mandle, Earl, 515 30 St., N. Bergen, N. J.
Martial & Scull, 1220 Broadway, N. Y. C.
Meggett, Arthur, 640 Madison Ave., N. Y. C.
Miller Co., H. Wood, 1545 Rockingham St., Davenport, Ia.
Miller, Frances T., 24 W. 55 St., N. Y. C.
Muffitt, J. Albert, 601 Liberty Trust Bldg., Philadelphia, Pa.
Muller, Theodore Carl, 9 Rockefeller Plaza, N. Y. C.
Muller-Munk, Peter, Carnegie Tech., Pittsburgh, Pa.
Nash, Ben, 10 Rockefeller Plaza, N. Y. C.
Nichols & Palma, 1 No. La Salle St., Chicago, Ill.
Olsen Designers, 160 W. Walton, Chi., Ill.
O'Neil, William, 50 Rockefeller Plaza, N. Y. C.
Orcutt, Philip Dana, 93 W. Cedar St., Boston, Mass.
Ormsby, James W., 247 East 37 St., New York, N. Y.
Pack, Jr., Harry S., 71 Kercheval Ave., Grosse Pointe Farms, Mich.
Parzinger, Tommi, 320 E. 57 St., N. Y. C.
Paullin, Mrs. Ethel Parsons, 51 West 10 St., N. Y. C.
Petrucelli, Antonio, 30 E. 20 St., N. Y. C.
Post Studios, Harold, Hartford, Conn.
Preis, Marion, 177 E. 87 St., N. Y. C.
Ressinger, Paul, Chicago, Ill.
Rideout, John Gordon, Caxton Bldg., Cleveland, Ohio
Rohde, Gilbert, 22 E. 60 St., N. Y. C.
Root, John, 3728 Lowell Ave., Chi., Ill.
Sakier, George, 40 W. 40 St., N. Y. C.
Sanders, Morris B., 219 E. 49 St., N. Y. C.
Saymon, Inc., Clarice, 9 Rockefeller Plaza, N. Y. C.
Scheele, Edwin H., 419 4th Ave., N. Y. C.
Simonson, Lee, 411 East 50 St., N. Y. C.
Slobodkin, Simon, 41 West 23 St., N. Y. C.
Spilman, Raymond, 7451 Woodward Ave., Detroit, Mich.
Stensgaard & Associates, Inc., W. L., 346 N. Justine St., Chicago, Ill.; 30 Rockefeller Plaza, N. Y. C.
Streng, Jan, Mason, N. H.
Sundberg & Ferar, 207 Stephenson Bldg., Detroit, Mich.
Superior Engineering, 189 W. Madison St., Chicago, Ill.
Swibold, Duane, 1406 Penobscot Bldg., Detroit, Mich.
Szabo, Bela, 607 W. 43 St., N. Y. C.
Teague, Walter Dorwin, 444 Madison Ave., N. Y. C.
Teegan, Otto, 5 East 57 St., N. Y. C.
Thelander, Clement J., 646 N. Michigan Ave., Chicago, Ill.
Trace & Warner, 155 N. Clark St., Chicago, Ill.
Tupper, Earl S., 147 7 St., Leominster, Mass.
Van Doren & Associates, Harold, 1217 Madison Ave., Toledo, Ohio
Van Veen, Stuyvesant, 24 W 96, N. Y. C.
Vassos, John, Comstock Hill, Norwalk, Conn.
Vavrik, Louis, 332 Colony Road, Rossford, Ohio
Versen, Kurt, 373 Fourth Ave., N. Y. C.
Voges, George Arthur, 389 Central St., Springfield, Mass.
Von Miklos, Josephine, 163 East 36 St., N. Y. C.
Von Nessen, Walter, 211 E. 49 St., N. Y. C.
Walker, George W., 701 New Center Bldg., Detroit, Mich.
Waltman & Associates, C. E., 737 N. Michigan Ave., Chicago, Ill.
Warner, Sidney G., School of Arch. & Design, University of Michigan, Ann Arbor.
Weill, Inc., Paul, 40 E. 49th St., N. Y. C.
Wieselthier, Vally, 301 East 38 St., N. Y. C.
Wilmet, Georges, 51 E. 42nd St., N. Y. C.
Wilson, Lawrence H., Stephenson Bldg., Detroit, Mich.
Wilson, Scott, 1 East 53 St., N. Y. C.
Winne, Elsa, 443 West 22 St., N. Y. C.
Wright, Russel, 130 East 40 St., N. Y. C.

EXTRUSION PROCESSORS

American Plastics Corp.
Bakelite Corp.
Buchsbaum & Co., S.
Canadian Buttons Ltd.
Carter Products Corp.

Addresses of companies listed appear on pages 470–474

Celluloid Corp.
Dow Chemical Co., The
du Pont de Nemours & Co., Inc., E. I.
Extruded Plastics, Inc.
Goodrich Co., The B. F.
Irvington Varnish & Insulator Co.
Michigan Molded Plastics, Inc.
Nixon Nitration Works
Phoenix Plastics Corp.
Pierce Plastics, Inc.
Resistoflex Corp.
Respro, Inc.
Rex Co., Inc., The
Surprenant Electric Insulation Co.

FABRICATORS, ACRYLICS

Ace Plastic Novelty Corp.
Acraglas Co.
American Fixture & Mfg. Co.
Beals, Norman
Bell & Co., B. B.
Bend-A-Lite Plastics
Brogan, Byard F.
Cel-O-Mat Co.
Classic Studio
Colonial Kolonite Co.
Coronet Novelty & Plastics
Crafts, Inc.
Creative Plastics Corp.
Croasdale & de Angelis
Curolite Products, Inc.
Donovan Smith Display Co.
Emeloid Co., Inc.
Gemloid Corp.
Glassolin Products
Grosfeld House, Inc.
Heiberg Mfg. Co.
House of Plastics
Industrial Arts, Inc., Red Bank, N. J.
Industrial Arts Co., Chicago
Industrial Plastics Co.
Keolyn Plastics Co.
King Mfg. Co., J. M.
Kippy Kit Co.
Kirk Mfg. Co.
La Mode Plastic Co., Inc.
Landers, Inc., Bert A.
Manning & Co., Don
Margon Plastics
Metalex, Inc.
Meyer Bros., Joseph H.
Musser & Co., Inc., H. M.
National Fabricating Co.
National Plastic Products Co.
Neo Designs
Noell Oliver & Harasty Corp.
Oppenheimer, Walter L.
Ortho Plastic Novelties, Inc.
Packard, J. S.
Paragon Wood Turning Co.
Parisian Novelty Corp.
Plastic Age, Inc.
Plastic Turning Co., Inc.
Plastics Forming Corp.
Ply-Tex Mfg. Co.
Prager, Leo
Precision Shapes, Inc.
Ross Studios, Jane
Scheuer Art Metal Mfg. Co.
Schwab & Frank, Inc.
Shoreham Mfg. Co.
Sillcocks-Miller Co.
Solar Plastic Products Co.
Steiner Studios, Cyrille
Stricker-Brunhuber Corp.
Swedlow-Aeroplastics Corp.
Swedlow-Lehman, Inc.
Thornton, George Q.
Thorpe, Dorothy C.
Turner Plastic Products Co.
U. S. Plastic Corp.
Valley Mfg. Co., The
Van Cleff, Wm.
Vazah, Inc.
Wilcox Co.

FABRICATORS, CASEIN

A. J. & K. Co., Inc.
American Phenolic Corp.
Baff Mfg. Co.
Button Corp. of America
Caldwell Products, Inc.
Commonwealth Plastics Co.
Dayton Insulating Molding Co.
Keolyn Plastics Co.
Lamicast Plastics
La Mode Plastic Co., Inc.
Lowe Co. Inc., E. S.
Morrell Corp., George
National Plastic Products Co.
Phoenix Plastics Corp.
Plano Molding Co.
Schwab & Frank, Inc.
Standard Plastics Co.
Synthetic Plastics Corp.
Timely Novelty Co.
United Comb & Novelty Co.
U. S. Plastic Corp.
Voges Mfg. Co., Inc.

FABRICATORS, CAST RESIN

Ace Plastic Novelty Corp.
A. J. & K. Co., Inc.
Alesite Corp.
American Phenolic Corp.
Baff Mfg. Co.
Bronzart Metals Co.
Button Corp., George W.
Caldwell Products, Inc.
Chicago Button & Buckle Co.
Classic Studio
Cleveland Plastics, Inc.
Colonial Kolonite Co.
Commonwealth Plastics Co.
Croasdale & de Angelis
Ditglo Mfg. Co., Inc.
Erisman, A. C.
Expert Celluloid Co., Inc.
Fontaine Products, Inc.
Galbas, Fred L.
General Products, Inc.
Gibbs Mfg.
H. G. Specialty Co.
Hurst, Inc.
Industrial Plastics, Caldwell, N. J.
Ivorycraft Co., Inc.
K. C. Plastic Fabricators
Keolyn Plastics Co.
King Mfg. Co., J. M.
Krest Mfg. Co.
Lamicast Plastics
La Mode Plastic Co., Inc.
Lapin Products, Inc.
Lowe Co., Inc., E. S.
Meyer Bros., Joseph H.
Monsanto Chemical Co., Plastics Div.
National Fabricating Co.
National Lock Co.
National Plastic Products Co.
New England Novelty Co.
New England Plastic Spec. Co.
Nichols Products Co., Inc.
Northwest Plastics, Inc.
Ortho Plastic Novelties, Inc.
Peacock Plastic Co.
Plastic Novelties, Inc.
Plastic Specialties, Inc.
Plastic Turning Co.
Plastik, Inc.
Regent Specialties, Inc.
Rex Products Corp.
Rogers Mfg. Co., The
Royson Plasticraft Co.
Scheuer Art Metal Mfg. Co.
Schwab & Frank, Inc.
Select Novelty Co., Inc.
Shoreham Mfg. Co.
Solar Plastic Products Co.
Standard Plastics Co.
Steiner Studios, Cyrille
Strauss Co., Louis
Swedlow-Lehman, Inc.
Turner, Douglas
Turner Plastic Prods. Co.
Uncas Mfg. Co.
United Comb & Novelty Co.
U. S. Plastic Corp.
Victory Molding Co.
Voges Mfg. Co., Inc., The

FABRICATORS, LAMINATES

(Punched and Fabricated Parts, Gear Blanks, Etc.)

Alden Products Co.
Alesite Corp.
Angus-Campbell Co.
Continental-Diamond Fibre Co.
Formica Insulation Co.
General Electric Co., Plastics Div.
Henderson, Paul P.
Insulating Fabricators, Inc., N. Y. C.
Insulating Fabricators, Inc., Boston
Kirby Co., The
Lamicoid Fabricators, Inc.
Marwedel, C. W.
Mica Insulator Co.
National Vulcanized Fibre Co.
Spaulding Fibre Co., Inc.
Synthane Corp.
Taylor Fibre Co.
Western Electro-Mechanical Co.
Westinghouse Elec. & Mfg. Co., Micarta Div.

FABRICATORS, PYROXYLIN AND CELLULOSE ACETATE

Athol Comb Co.
Auburn Button Works, Inc.
Bachmann Bros., Inc.
Baff Mfg. Co.
Berkander, Geo. F.
Celluplastic Corp.
Celoid Mfg. Co., The
Classic Studio
Cleveland Plastics, Inc.
Cotan Corp.
Cruver Mfg. Co.
Elkloid Co., The
Emeloid Co., The
Felsenthal & Sons, G.
Foster Grant Co., Inc.
Gemloid Corp.
Hurst, Inc.
Insel Co., The
Johnson Fare Box Co.
Keolyn Plastics Co.
Kingman Co., E. B.
Kippy Kit Co.
Lamicast Plastics
Lordent Co., The
Markilo Co.
National Plastic Products Co.
Nichols Products Co., Inc.
Parisian Novelty Corp.
Plastic Turning Co.
Plastics, Inc.
Plastics Forming Corp.
Plastik, Inc.
Quick Point Pencil Co.
Respro, Inc.
Rex Products Corp.
Salz Bros., Inc.
Schwab & Frank, Inc.
Solar Plastic Products Co.
Standard Plastics Co.
Tilton-Cook Co.
United Comb & Novelty Co.
U. S. Plastic Corp.
Van Arnam Mfg. Co.
Williams & Marcus Co.

FABRICATORS, PYROXYLIN

(For Fabrics and Coatings)

Athol Manufacturing Co.
Boston Woven Hose and Rubber Co.
Bowen Mills, Inc.
Carpenter & Co., L. E.
Chase & Co., L. C.
Classic Studio
Columbus Coated Fabrics Co.
Cotan Corp.
Cotex Corp.
Davis, Kraus & Miller
Federal Leather Co.
Holliston Mills, The
Interlaken Mills
Keratol Co., The

Lamicast Plastics
Landers Corp.
Masland Duraleather Co.
Pantasote Leather Co.
Permatex Fabrics Co., The
Respro, Inc.
St. Clair Rubber Co.
Schwab & Frank, Inc.
Standard Plastics Co.
Standard Textile Prods. Co.
Textileather Corp.
Western Shade Cloth Co.
Weymouth Art Leather Co.
Zapon Co., The

FABRICATORS, RUBBER MOLD CASTING

Art Plastic Co.
Branagh & Bowen
Castaing, C. K.
Ettel Studios
Galvanic Art Studios
Marbello Art Craft Co.
Stensgaard & Associates, W. L.
Wein, Samuel

FABRICATORS, VINYL

American Phenolic Corp.
Bronzart Metals Co.
Carbide and Carbon Chemicals Corp., Vinylite Div.
Celluplastic Corp.
Classic Studio
Cleveland Plastics, Inc.
Croasdale & de Angelis
Gemloid Corp.
Insel Co., The
Lamicast Plastics
National Plastic Products Co.
Nichols Products Co., Inc.
Parisian Novelty Corp.
Plastics Forming Corp.
Resistoflex Corp.
Schwab & Frank, Inc.
Standard Plastics Co.
Tupper Co., Earl S.
U. S. Plastic Corp.

LAMINATORS

Brandywine Fiber Prods. Co.
Continental-Diamond Fibre Co.
Detroit Paper Products Corp.
Formica Insulation Company
Franklin-Fibre-Lamitex Corp.
General Electric Co., Plastics Dept.
General Laminated Products, Inc.
Haskelite Mfg. Corp.
Masonite Corp.
Mica Insulator Co.
Micarta Fabricators of Illinois
National Vulcanized Fibre Co.
Panelyte Corp.
Parkwood Corp. (Woven Veneers)
Richardson Co.
Spaulding Fibre Co., Inc.
Standard Plastics Co.
Synthane Corp.
Taylor Fibre Co.
Westinghouse Elec. & Mfg. Co., Micarta Div.
Wilmington Fibre & Specialty Company

MODEL MAKERS

Abel, Frank J.
American Model R. R. Co., Inc.
Bach, Alfons
Bacon & Weber
Brigham, Richard B.
Bronzart Metals Co.
Classic Studio
Croasdale & de Angelis
Engineering Specialties, Inc.
Faber, Guy S.
Kunst Co., The, John
Lamicast Plastics
National Lock Co.
Nichols Products Co., Inc.
Peacock Plastic Co.
Standard Plastics Co.
Stricker-Brunhuber Corp.
Swedlow-Lehman, Inc.

EDUCATIONAL INSTITUTIONS,

(Design)

California
California Graduate School of Industrial Design, 425 W. Colorado St., Pasadena
Illinois
School of Design, 247–257 E. Ontario St., Chicago
Massachusetts
Massachusetts School of Art, Department of Education, Boston
Michigan
University of Michigan, College of Architecture & Design, Ann Arbor
New York
Cooper Union Art Schools, N. Y. C.
New York University, School of Architecture and Allied Arts, 1071 Sixth Avenue, N. Y. C.
Pratt Institute, Brooklyn, N. Y.
Universal School of Handicrafts, 1270 Sixth Avenue, N. Y. C.
Ohio
John Adams High School, East 116th St. & Corlett Ave., Cleveland

(Technical)

Alabama
University of Alabama, School of Chemistry, Metallurgy and Ceramics, University
California
Plastics Industries Technical Institute, 186 S. Alvarado St., Los Angeles
Delaware
University of Delaware, School of Engineering, Newark
Florida
University of Florida, College of Engineering, Gainesville
Illinois
Armour Institute of Technology, Chicago
Indiana
Purdue University, School of Chemical & Metallurgical Engineering, Lafayette
Iowa
Iowa State College, Department of Chemical & Mining Engineering, Ames
Massachusetts
Massachusetts Institute of Technology, Department of Chemical Engineering, Cambridge
Michigan
Michigan State College of Agriculture and Applied Science, East Lansing
Missouri
Washington University, St. Louis
New York
Columbia University, Department of Chemical Engineering, New York
Polytechnic Institute of Brooklyn
New York State College of Forestry, Syracuse University, Syracuse
Rensselaer Polytechnic Institute, Department of Chemical Engineering and Chemistry, Troy
North Carolina
North Carolina State College of Agriculture & Engineering, University of North Carolina, Raleigh
Ohio
University of Toledo, Toledo
Pennsylvania
Carnegie Institute of Technology, Pittsburgh
Mellon Institute of Industrial Research, Department of Chemistry, University of Pittsburgh, Pittsburgh
Philadelphia College of Pharmacy & Science, Philadelphia
Texas
Agricultural and Mechanical College of Texas, Department of Chemistry and Chemical Engineering, College Station
Canada
McGill University, Department of Chemistry, Montreal, Quebec

(Vocational)

Plastics Industries Technical Institute, 186 S. Alvarado St., Los Angeles, Cal.

FOREIGN

Canada

Alberta
Plastic Displays, 9926—111th St., Edmonton
Ontario
Branagh & Bowen, 81 Peter St., Toronto
Canadian General Electric Ltd., Peterborough
Canadian Westinghouse Co., Ltd., Hamilton
Dominion Button Mfrs., Ltd., Kitchener
Duplate Safety Glass Co., Ltd., Oshawa
French Ivory Products Co., 1475 Queen St. W., Toronto
Percy Hermant Ltd., Hermant Bldg., Toronto
Modern Machine Co., 344 Queen St., Ottawa
W.E. Phillips Glass Co. Ltd., Oshawa
Joseph Stokes Rubber Co., Welland
M. Wintrob & Sons, 30 Duncan St., Toronto
Quebec
Bolta Plastics Ltd., Granby
Canadian Buttons Ltd., 1850 St. Antoine St., Montreal
Hale Brothers, 6230 Chambord St., Montreal
Mack Molding Co., Waterloo
Moulded Plastic Specialties, 388 Craig St. W., Montreal
Northern Electric Co., 1261 Shearer St., Montreal
Olympia Mfg. Works, 3842 St. Lawrence Blvd., Montreal
Plastex Corp. Ltd., 6259 Notre Dame St. E., Montreal
Plastic Mfg. Co. of Canada, 43 St. Lambert St., Ville de St. Therese

South America

Buenos Aires, Brazil
Anelit Soc. de Resp. Ltda.
Banham Bros & Cia.
Eastman Kodak Cia de S. A.
Formalit—Sociedad Resp. Ltda.
Friedman Droge & Cia
Kahe & Cia
Kalochi & Cia
Manufactures Bakelite Supes
Pfanner & Lau
RCA Victor de Argentina S.A.
Sao Paulo, Brazil
Byington & Cia, 127 Av. Paulisla
Companhia Industrial—Sao Paulo & Rio
S. A. Fabrica Orion, 91 Joaquim Carlos
Molinari Fantazini
Santiago, Chile
Productos Bakelita
Shyf & Cia
Otto W. Sturm

Mexico

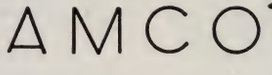
Mexico, D. F.
Eca-Plastica S.A.
Plasticmex S.A.
Perez, Guadalajara
Cia Moldeado de Guadalajara

Addresses of companies listed appear on pages 470–474

MOLDERS' MARKINGS



Accurate Molding Corp., Brooklyn, N. Y.



Accurate Molding Corp., Brooklyn, N. Y.



The Ackerman Rubber & Plastic Molding Co. Cleveland, Ohio



Advance Molding Corp., New York, N. Y.



Alden Products Corp. Brockton, Mass.



Allied Plastics Corp., Los Angeles, Cal.



American Hard Rubber Co., Butler, N. J.



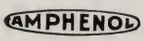
American Insulator Corp., New Freedom, Pa.



American Molding Co., San Francisco, Cal.

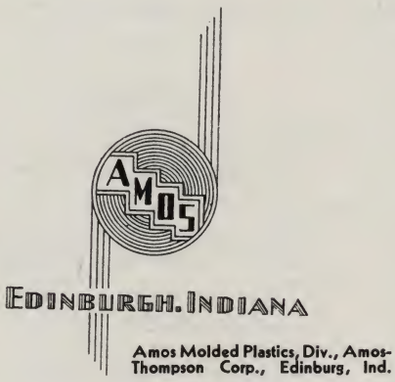


American Molded Products Co., Chicago, Ill.





American Phenolic Corp., Chicago, Ill.



Amos Molded Plastics, Div., Amos-Thompson Corp., Edinburg, Ind.



Anchor Cap & Closure Corp., Long Island City, New York



Armstrong Cork Products Co., Lancaster, Pa.



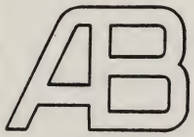
The Arrow-Hart & Hegeman Electric Co., Hartford, Conn.



Associated Attleboro Mfrs., Inc., Attleboro, Mass.



Atlantic Plastics, Cleveland, Ohio



Auburn Button Works, Auburn, N. Y.



Bay Manufacturing Co., Div., Electric Auto-Lite Co., Bay City, Michigan



Belmont Molded Plastics Inc., Cincinnati, Ohio



Geo. F. Berkander, Providence, R. I.



Boonton Molding Co., Boonton, N. J.



Bridgeport Moulded Products, Inc., Bridgeport, Conn.



Bryant Electric Co., Bridgeport, Conn.



Chicago Molded Products Corp., Chicago, Ill.



Cincinnati Molding Co., Cincinnati, Ohio



Columbus Plastic Products, Inc., Columbus, Ohio

MOLDERS' MARKINGS



Colt's Patent Fire Arms Mfg., Co., Hartford, Conn.



Consolidated Molded Products Corp., Scranton, Pa.



Cruver Manufacturing Co., Inc., Chicago, Ill.



Cutler-Hammer, Inc., Milwaukee, Wisconsin



Dalmo Manufacturing Co., San Francisco, Cal.



Harry Davies Molding Co., Chicago, Ill.



Dayton Insulating Molding Co., Dayton, Ohio



Diemolding Corp., Canastota, N. Y.



Eclipse Moulded Products Co., Milwaukee, Wis.



The Emeloid Co., Inc., Arlington, N. J.



Erie Resistor Corp., Erie, Pa.



Firestone Tire & Rubber Co., Akron, Ohio



Franklin Plastic & Die Casting, Div. Baldwin Laboratories, Inc., Franklin, Pa.



Garfield Mfg. Co., Garfield, N. J.



Gemloid Corp., Elmhurst Long Island, N. Y.



General Electric Co., Pittsfield, Mass.



General Industries, Inc., Elyria, Ohio



General Molding Co., Rockledge, Pa.



Jimmie Gillum Plastic Molding, Los Angeles, Calif.



Gits Molding Corporation, Chicago, Ill.



The Grigoleit Co., Decatur, Ill.



Wm. Gulliksen Machinery Co., Newton Lower Falls, Mass.



Imperial Molded Products Corp., Chicago, Ill.



Industrial Molded Products Co., Chicago, Ill.



Ingersoll-Rand Co., New York, N. Y.





Insulation Manufacturing Co. Inc., Brooklyn, N. Y.



International Molded Plastics, Inc., Cleveland, Ohio



H. Jamison, New York, N. Y.



Keasbey & Mattison Co., Ambler, Pa.



Kellogg Switchboard and Supply Co., Chicago, Ill.



Kuhn and Jacob Moulding & Tool Co., Trenton, N. J.

MOLDERS' MARKINGS



Kurz-Kasch, Inc., Dayton, Ohio



Mack Molding Co., Inc., Wayne, N. J.



Martindell Molding Co. Trenton, N. J.



The Thomas Mason Co., Inc. Stamford, Conn.



McDonald Mfg. Co., Los Angeles, Cal.



Mechanical Die & Tool Co., Brooklyn, N. Y.



Mico, Inc., Millerton, N. Y.



Michigan Molded Plastics, Inc., Dexter, Mich.



Michigan Plastics Corp- St. Paul, Minn.



Midwest Molding & Mfg. Co., Chicago, Ill.



Elmer E. Mills Corporation, Chicago, Ill.



Modern Plastics Corp. Benton Harbor, Mich.



Molded Insulation Co., Philadelphia, Pa.



Molding Corp. of America, Providence, R. I.



National Lock Co. Rockford, Ill.



National Plastics, Inc., Knoxville, Tenn.



Northern Industrial Chemical Co., S. Boston, Mass.



Bell Mfg. Co., Division of Northern Industrial Chemical Co., S. Boston, Mass.



Northwest Plastics, Inc., St. Paul, Minn.



Norton Laboratories, Lockport, N. Y.



Oris Mfg. Co., Thomaston, Conn.



Owens-Illinois Glass Co., Toledo, Ohio



The Panelyte Corp., New York, N. Y.



Peerless Molded Plastics, Inc., Toledo, Ohio



Phoenix Metal Cap Co., Chicago, Ill.



Pittsburgh Plastics Co., Inc., New Kensington, Pa.



Plastic Molding Corp., Cincinnati, Ohio



Plastic Molding Corporation, Sandy Hook, Conn.



Plastics, Inc., Bradley Beach, N. J.



Raymond Laboratories, St. Paul, Minn.



Rathbun Molding Corp., Salamanca, N. Y.



Recto Molded Products Co., Cincinnati, O.



F. E. Reinhold Co., Los Angeles, Cal.





Reynolds Molded Plastics, Div. Reynolds Spring Co., Jackson, Michigan

MOLDERS' MARKINGS

INSUROK

The Richardson Co., Melrose Park, Chicago, Ill.

Royal Molding Co., Providence, R. I.

SHAW

Shaw Insulator Co., Irvington, N. J.

S

Shaw Insulator Co., Irvington, N. J.

Sinko

Sinko Tool & Mfg. Co. Chicago, Ill.

Specialty Insulation Mfg. Co., Inc., Hoosick Falls, N. Y.

Standard Cap & Molding Co., Baltimore, Md.

Sterling Plastics Co., Newark, N. J.

Jos. Stokes Rubber Co., Trenton, N. J.

Synthetic Moulded Products, Inc., Wakefield, R. I.

Tech-Art Plastics Co., Long Island City, N. Y.

Terkelsen Machine Co. Boston, Mass.

Thermo-Plastics Div., Standard Products Co., St. Clair, Mich.

Union Insulating Co., Parkersburg, W. Va.

Universal Molding Co., San Francisco, Cal.

Universal Plastics Corp., New Brunswick, N. J.

Ward Plastic & Rubber Co., Ferndale, Mich.

TRADE MARK

Warren Plastics Corp., Warren, Pa.

Waterbury Button Co., Waterbury, Conn.

Watertown Mfg. Co., Watertown, Conn.

WESTINGHOUSE ELECTRIC

Westinghouse Elec. & Mfg. Co., Trafford, Pa.

Wheeling Stamping Co., Wheeling, W. Va.

Windman Brothers, Los Angeles, California

The Woodruff Co., Auburn, N. Y.

Worcester Moulded Plastics Co., Worcester, Mass.

Zenith Plastics, Inc., Cleveland, Ohio

Ziwel Plastics Corp., Dover, Ohio

DIRECTORY OF TRADE NAMES

AND MANUFACTURERS OF PLASTICS LISTED IN PROPERTIES CHART

Phenol-Formaldehyde Molding Compounds

Bakelite	Bakelite Corp., 247 Park Ave., New York
Catalin	Catalin Corp., 1 Park Ave., New York
Celeron	Continental Diamond Fibre Co., Newark, Del. N. Y. office: 230 Park Ave.
Durez	Durez Plastics & Chemicals, Inc., 710 E. Walck Rd., N. Tonawanda, N. Y. N. Y. office: 250 Park Ave.
Durite	Durite Plastics, 5010 Summerdale Ave. (near Roosevelt Blvd.), Philadelphia, Pa.
Heresite	Heresite and Chemical Co., 822 S. 14th St., Manitowoc, Wis.
Indur	Reilly Tar & Chemical Corp., 500 Fifth Ave., New York, N. Y.
Insurok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
Makalot	Makalot Corp., 262 Washington St., Boston, Mass.
Neillite	Watertown Mfg. Co., Watertown, Conn.
Resinox	Resinox Corp., Sub. Monsanto Chemical Co., 30 Rockefeller Pl., N. Y. C.
Textolite	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Uniplast	Universal Plastics Co., 235 Jersey Ave., New Brunswick, N. J.

Phenol-Formaldehyde Laminated Products

Aqualite	National Vulcanized Fibre Co., Wilmington, Del.
Celeron	Continental Diamond Fibre Co., Newark, Del. N. Y. office: 230 Park Ave.
Dilecto	Do.
Duraloy	Detroit Paper Products Corp., 5800 Domine St., Detroit, Mich.
Formica	Formica Insulation Co., 4672 Spring Grove Ave., Cincinnati, Ohio N. Y. office: 101 Park Ave.
Insurok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
Lamicoid	Mica Insulator Co., 200 Varick St., New York, N. Y.
Micarta	Westinghouse Electric & Mfg. Co., Micarta Div., Trafford, Pa.
Ohmoid	Wilmington Fibre Specialty Co., East Wilmington, Del.
Panelyte	Panelyte Corp., 230 Park Ave., New York
Phenolite	National Vulcanized Fibre Co., Wilmington, Del.
Spauldite	Spaulding Fibre Co., 313 Wheeler St., Tonawanda, N. Y. N. Y. office: 484 Broome St.
Synthane	Synthane Corp., Oaks, Pa.
Taylor	Taylor Fibre Co., Norristown, Pa. N. Y. office: 90 West St.
Textolite	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Ucinite	United-Carr Fastener Corp., 31 Ames St., Cambridge, Mass.

Phenol-Formaldehyde Cast Resins

Bakelite	Bakelite Corp., 247 Park Ave., New York
Catalin	Catalin Corp., 1 Park Ave., New York
Gemstone	A. Knoedler Co., Lancaster, Pa.
Marbiette	Marblette Corp., 37–21 30th St., Long Island City, N. Y.
Monsanto C.P. Opalon	Plastics Div., Monsanto Chemical Co., Springfield, Mass. N. Y. office: 30 Rockefeller Plaza

Phenol-Furfural Resins

Durite	Durite Plastics, 5010 Summerdale Ave. (near Roosevelt Blvd.), Philadelphia, Pa.

Urea-Formaldehyde Molding Compounds

Bakelite	Bakelite Corp., 247 Park Ave., New York
Beetle	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York
Plaskon	Plaskon Co., Inc., 2112 Sylvan Ave., Toledo, Ohio N. Y. office: 41 E. 42nd St.
Uformite	Resinous Products & Chemicals Co., 222 W. Washington Sq., Philadelphia, Pa.

Urea-Formaldehyde Laminated Products

Beetle	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York
Formica	Formica Insulation Co., 4671 Spring Grove Ave., Cincinnati, Ohio
Insurok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill.
Micarta	Westinghouse Electric & Mfg. Co., Micarta Div., Trafford, Pa.

Aniline-Formaldehyde Resin

Cibanite	Ciba Co., Inc., 627 Greenwich, N. Y. C.

Vinyl Resins

Alvar	Shawinigan Prod. Corp., 350 Fifth Ave., N. Y. C.
Butacite	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del.
Butvar	Shawinigan Products Corp., 350 Fifth Ave., New York, N. Y.
Formvar	Do.
Gelva	Do.
Vinylite	Carbide & Carbon Chemicals Corp., 30 E. 42nd St., New York, N. Y.

Acrylate and Methacrylate Resins

Crystalite	(Molding compound)	Röhm & Haas Co., Inc., 222 W. Washington Sq., Philadelphia, Pa.
Lucite	(Molding compound & cast resin)	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J. N. Y. office: 350 Fifth Ave.
Plexiglas	(Cast resin)	Röhm & Haas Co., Inc., 222 W. Washington Sq., Philadelphia Pa.

Styrene Resins

Bakelite	Bakelite Corp., 247 Park Ave., New York
Styron	Dow Chemical Co.. Midland, Mich.
Monsanto	Plastics Div., Monsanto Chemical Co., Springfield, Mass.

Shellac Compounds

Complac	Poinsettia Inc., Pitman, N. J.
Compo-Site	Compo-Site, Inc., 207 Astor St., Newark, N. J.
Harvite	Siemon Co., Bridgeport, Conn. N. Y. office: 145 Varick St.
Lacanite	Consolidated Molded Products Corp., 1938 Modern St., Scranton, Pa. N. Y. office: 1776 B'way
———	T. F. Butterfield, Inc., 58 Rubber St., Naugatuck, Conn. N. Y. office: 303 Fifth Ave.
———	Waterbury Button Co., Waterbury, Conn. N. Y. office: 1133 B'way

Cold Molded—Bituminous Type (Non-Refractory)

Aico	American Insulator Corp., New Freedom, Pa. N. Y. office: 101 Park Ave.
Amerine (phenolic)	Do.
Cetec-Non-Refractory	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Ebrok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
Gummon	Garfield Mfg. Co., Wallington Rd., Garfield, N. J.
Okon	American Hard Rubber Co., 11 Mercer St., New York
Thermoplax	Cutler-Hammer, Inc., 1333 W. St. Paul Ave., Milwaukee, Wis. N. Y. office: 8 W. 40th St.

Cold Molded—Ceramic Type (Refractory)

Aico -5	American Insulator Corp., New Freedom, Pa.
Alphide	Standard Plastics Corp., 106 B'way, Jersey City, N. J.
Cetec-Refractory	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Coltstone	Colt's Patent Fire Arms Mfg. Co., 1935 Van Dyke Ave., Hartford, Conn. N. Y. office: 20 Vesey St.
Hemit	Garfield Mfg. Co., Wallington Rd., Garfield, N. J.

Rubber Derivatives and Rubber-like Resins

Amerite	Aqueous dispersion	American Anode, Inc., Akron, Ohio
Corprene	Synthetic rubber with ground cork	Armstrong Cork Products Co., Liberty St., Lancaster, Pa.
Flamenol	Vinyl chloride resin	General Electric Co., 1 River Rd., Schenectady, N. Y.
Kogene	Synthetic elastic	B. F. Goodrich Co., 454 S. Main St., Akron, Ohio
Koroseal	Vinyl chloride resin	Do.
Marbo	Chlorinated rubber	Marbo Products Corp., 469 E. Ohio St., Chicago, Ill.
Marbon	Do.	Do.
Neoprene	Chloroprene	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del. N. Y. office: 350 Fifth Ave.
Parlon	Chlorinated rubber	Hercules Powder Co., 999 Market St., Wilmington, Del. N. Y. office: 20 E. 40th St.
Pliofilm	Rubber hydrochloride	Goodyear Tire & Rubber Co., Inc., 1400 Cartwright St., Akron, Ohio N. Y. office: 600 W. 58th St.
Plioform	Modified isomerized rubber	Do.
Pliolite	Do.	Do.
Resistoflex PVA	Polyvinyl alcohol tubing	Resistoflex Corp., Dover, N. J.
Thiokol	Organic polysulfide	Thiokol Corp., 780 N. Clinton Ave., Trenton N. J.

Hard Rubber

Ace	American Hard Rubber Co., 11 Mercer St., New York, N. Y.
Luzerne	Luzerne Rubber Co., Dewey St., Trenton, N. J.
Rub-tex	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
———	Joseph Stokes Rubber Co., 322 Webster St., Trenton, N. J.
———	Vulcanized Rubber Co., 2 E. 29th St., New York, N. Y.

Casein

Ameroid	American Plastics Corp., 50 Union Square New York, N. Y.
Gala	George Morrell Corp., Muskegon Hts., Mich.
Galorn	Do.

Ethylcellulose

Ethocel	Dow Chemical Co., 919 Jefferson Ave., Midland, Mich.
———	Hercules Powder Co., 999 Market St., Wilmington, Del. N. Y. office: 20 E. 40th St.

Cellulose Acetate

Bakelite	Bakelite Corp., 247 Park Ave., New York
Lumarith	Celluloid Corp., 10 E. 40th St., New York, N. Y.
Monsanto C.A. Fibestos	Plastics Div., Monsanto Chemical Co., Springfield, Mass. N. Y. office: 30 Rockefeller Plaza
Nixonite	Nixon Nitration Works, Nixon, N. J.
Plastacele	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J. N. Y. office: 350 Fifth Ave.
Tenite	Tennessee Eastman Corp., Kingsport, Tenn. N. Y. representative: 10 E. 40th St
———	Hercules Powder Co., 999 Market St. Wilmington, Del.

Cellulose Acetate Butyrate

Tenite II	Tennessee Eastman Corp., Kingsport, Tenn. N. Y. representative: 10 E. 40th St.

Cellulose Nitrate (Pyroxylin)

Celluloid	Celluloid Corp., 10 E. 40th St., New York, N. Y.
Monsanto C.N.	Plastics Div., Monsanto Chemical Co., Springfield, Mass. N. Y. office: 30 Rockefeller Plaza
Nixonoid	Nixon Nitration Works, Nixon, N. J.
Pyralin	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J. N. Y. office: 350 Fifth Ave.

Coumarone-Indene Resins

Cumar	Barrett Co., 40 Rector St., New York, N. Y.
Neville Resin	Neville Co., Neville Island Post Office, Pittsburgh, Pa.
Nevindene	Do.

Lignin Plastics

Benaloid	Uncured lignin sheets	Masonite Corp., Laurel, Miss.
Benalite	Cured lignin sheets	Do.

Varnish and Lacquer Resins

Trade Name	Composition	Manufacturer
Abalyn	Methyl abietate	Hercules Powder Co., 999 Market St., Wilmington, Del.
Acryloid	Acrylic	Resinous Products & Chemical Co., Inc., 222 W. Washington Square, Philadelphia
Acrysol	Do.	Do.
Aero Ester Gum	Rosin-glycerol	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Akco	Phenolic	Do.
Amberlac	Alkyd	Resinous Products & Chemical Co., Inc., 222 W. Washington Square, Philadelphia
Amberlite	Laminating phenolic	Do.
Amberol	Phenolic	Do.
Aquaplex	Alkyd emulsion	Do.
Aroclor	Chlorinated diphenyl	Monsanto Chemical Co., 1700 S. 2nd St., St. Louis, Mo.
Bakelite	Phenolic	Bakelite Corp., 247 Park Ave., New York
Beckacite	Modified phenolic	Reichhold Chemicals, Inc., 601 Woodward Hts. Blvd., Detroit, Mich.
Beckamine	Urea-formaldehyde	Do.
Beckolin	Synthetic oil	Do.
Beckosol	Do.	Do.
Beckopol	Phenolated copal	Do.
Beetle	Urea-formaldehyde	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Dulux	Alkyd	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del.
Duraplex	Alkyd	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Durez	Phenolic	Durez Plastics & Chemicals Inc., N. Tonawanda, N. Y.
Esterol	Alkyd	Paramet Chemical Corp., 1017 Forty-fourth Ave., Long Island City, N. Y.
G	Glycerol-phthalic anhydride	Makalot Corp., 262 Washington St., Boston, Mass.
Glyptal	Alkyd	General Electric Co., Bridgeport, Conn.
Hercolyn	Hydrogenated methyl abietate	Hercules Powder Co., 999 Market St., Wilmington, Del.
Imperial Ester	Rosin-glycerol	J. D. Lewis, Inc., 68 Traverse St., Providence, R. I.
Kopol	Esterified copals	Reichhold Chemicals, Inc., 601 Woodward Hts. Blvd., Detroit, Mich.
Lewisol	Alkyd and phenolic	J. D. Lewis, Inc., 68 Traverse St., Providence, R. I.
Makalot	Alkyd, phenolic, and urea-formaldehyde	Makalot Corp., 262 Washington St., Boston, Mass.
Mirasol	Alkyd	Carbogen Chem. Co., Garwood, N. J.
Paradura	Phenolic	Paramet Chemical Corp., 1017 Forty-fourth Ave., Long Island City, N. Y.
Paramet Ester Gum	Rosin-glycerol	Do.
Paranol	Phenolic	Do.
Paraplex	Alkyd	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Petrex	Terpinene maleic anhydride	Hercules Powder Co., 999 Market St., Wilmington, Del.
Phenac	Phenolic	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Piccolyte	Terpene resin	Penn Industrial Chem. Co, Clairton, Pa.
Piccoumaron	Do.	Do.
Rauzene	Phenolic	U. S. Industrial Alcohol Co., 480 Frelinghuysen Ave., Newark, N. J.
Rauzene Ester	Rosin-glyceride	Do.
Rauzite	Urea-formaldehyde	Do.
Rauzone	Alkyd	Do.
Rezyl	Alkyd	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Santolite	Toluene sulfonamid formaldehyde	Monsanto Chemical Co., 1700 S. 2nd St., St. Louis, Mo.
Staybelite	Hydrogenated rosin	Hercules Powder Co., 999 Market St., Wilmington, Del.
Super-Beckacite	Pure phenolic	Reichhold Chemicals, Inc., 601 Woodward Hts. Blvd., Detroit, Mich.
Teglac	Alkyd	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Uformite	Laminating urea-formaldehyde resin	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Vinsol	Modified rosin	Hercules Powder Co., 999 Market St., Wilmington, Del.
Vinylite	Vinyl resin	Carbide & Carbon Chemicals Corp., 30 E. 42nd St., New York

Miscellaneous Plastics

Abopon	Boro-phosphate	Glyco Products Co., Inc., 148 Lafayette St., N. Y.
Acwalite	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Adheso Wax	Synthetic wax	Glyco Products Co., Inc., 148 Lafayette St., N. Y.
Amphenol	Polystyrene	American Phenolic Corp., 250 W. Van Buren St., Chicago, Ill.
Ameray	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Amer-glo	Do.	Do.
Amerith	Do.	Do.
Aquaresin	Glycol borborate	Glyco Products Co. Inc., 148 Lafayette St., N. Y
Arcolite	Phenolic	Consolidated Molded Products Corp., 1938 Modern St., Scranton, Pa.
Art-Y-Zan	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Beetleware	Urea moldings	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Bonnyware	Urea moldings	Reynolds Molded Plastics Div., Reynolds Spring Co., Jackson, Mich.
Carterite	Resin - pulp molding compound	Dispersion Products, Needham Hts., Mass.
Celastic	Pyroxylin box toes	Celastic Corp., Arlington, N. J.
Cellanite	Phenolic laminated	Continental Diamond Fibre Co., Newark, Del.
Celeron	Phenolic impregnated fabric	Continental Diamond Fibre Co., Newark, Del.
Cellophane-(Du Pont)	Regenerated cellulose wrapping	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington. Del.
Cellulak	Shellac paper-laminated tubing	Continental Diamond Fibre Co., Newark, Del.
Cel-O-Glass	Acetate-coated wire screen	Acetol Products, Inc., New York, N. Y.
Charmour	Cellulose acetate	Celluloid Corp., 10 E. 40th St., New York
Cibanoid	Urea-formaldehyde resin	Do.
Clair de Lune	Cellulose acetate	Celluloid Corp., 10 E. 40th St., New York
Clearsite	Cellulose acetate containers	Hygienic Tube & Container Co., Newark, N. J.
Colasta	Phenolic, etc.	Specialty Insulation Mfg. Co., 55 Center Ave., Hoosick Falls, N. Y.
Colfite	Graphited laminate	Formica Insulation Co., Cincinnati, Ohio
Coltrock	Phenolic	Colt's Patent Fire Arms Mfg. Co., 1935 Van Dyke Ave., Hartford, Conn.
Crystalex	Methacrylate denture compound	Detroit Dental Mfg. Co., 6801 12 St., Detroit, Mich.
Elastiglass	Vinyl copolymer resin	S. Buchsbaum & Co., 243 E. Huron St., Chicago, Ill.
Ethofoil	Ethylcellulose film	Dow Chemical Co., Midland, Mich.
Fiberlac	Cellulose nitrate lacquer	Plastics Div., Monsanto Chem. Co. Springfield, Mass.
Flexoresin	Glycol and glyceryl phthalates	Glyco Products Co., 148 Lafayette St., N. Y.
Flexowax	Synthetic wax	Do.
Gemloid	Pyroxylin and cellulose acetate	Gemloid Corp., Albion Ave., Elmhurst, L. I.
Glycene	Alkyd denture	Bakelite Corp., 247 Park Ave., New York
H-Scale	Synthetic pearl essence	Celluloid Corp., 10 E. 40th St., New York
Halowax	Chlorinated naphthalenes	Halowax Corp., 247 Park Ave., New York
Haskelite	Plywood bonded with phenolic resin	Haskelite Mfg. Co., 208 W. Washington St., Chicago, Ill.
Haveg	Phenolic-asbestos	Haveg Corp., E. Newark, Del.
Hemcoware	Urea moldings	Bryant Electric Co., 1934 Weaver Ave., Bridgeport, Conn.
Hercose AP	Cellulose acetate propionate	Hercules Powder Co., 999 Market St., Wilmington, Del.
Herculoid	Cellulose nitrate	Do.
Hycoloid	Cellulose nitrate containers	Hygienic Tube & Container Co., Newark, N. J.
Hydroresin A	Water soluble resin	Glyco Products Co., 148 Lafayette St., N. Y.
Inceloid	Acetate packaging material	American Products Mfg. Co., New Orleans, La.
Ivaleur	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Kodaloid	Cellulose nitrate	Eastman Kodak Co., Rochester, N. Y.
Kodapak	Cellulose acetate	Do.
Lauxite	Urea-formaldehyde- zinc chloride, resin for plywood	I. F. Laucks, Inc., 116 S. Niagara St., Lockport, N. Y.
Lucitone	Methacrylate denture compound	L. D. Caulk Co., Milford, Del.
Lumarith Protectoid	Cellulose acetate packaging material	Celluloid Corp., 10 E. 40th St., New York
Luxene	Phenolic denture	Bakelite Corp., 247 Park Ave., New York
Maizite	Alcohol soluble protein	Prolamine Products, Inc., 100 E. 42nd St., New York
Melocol	Polyamide formaldehyde	Ciba Co., Inc., 627 Greenwich St., New York
Melopas	Do.	Do.
Micabond	Bonded mica	Continental Diamond Fibre Co., Newark, Del.
Micanite	Mica	Mica Insulator Co., 200 Varick St., New York
Micoid	Phenolic laminated	Do.
Nevillac	Phenol-indene coumarone	Neville Co., Neville Island Post Office, Pittsburgh, Pa.
Nevillite	Hydrocarbon	Do.
Norbo	Phenolic resin	Bakelite Corp., 247 Park Ave., New York
Parkwood	Acetate - impregnated woven veneer	Parkwood Corp., Leominster, Mass.
Parkwood-Textolite	Phenolic- or urea-impregnated woven veneer	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Plexigum	Acrylic resin for laminated glass	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia
Primal	Acrylic resin for leather finishes	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia.
Protecto	Cellulose acetate box toe material	Celluloid Corp., 10 E. 40th St., New York, N. Y.
Proxyl	Pyroxylin denture	Lee S. Smith & Son Mfg. Co., 7325 Pa. Ave., Pittsburgh, Pa.
Prystal	Cast phenolic (clear)	Catalin Corp., 1 Park Ave., New York
Resisto	Pyroxylin box toe material	Celluloid Corp., 10 E. 40th St., New York
Resovin	Vinyl denture	S. S. White Dental Mfg. Co., 211 S. 12th St., Philadelphia, Pa.
Revolite	Cloth impregnated with phenolic resin	Zapon Div., Atlas Powder Co., Stamford, Conn.
Reziwood	Phenolic laminated wood	I. F. Laucks Inc., Maritime Bldg., Seattle, Wash.
Rheolan	Thermoplastic pitch-like solid	Glyco Products Co., 148 Lafayette St., New York
RHonite	Urea resin	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia
RHoplex	Acrylic resin for textile finishes	Do.
Safety Samson	Cellulose acetate film base	Celluloid Corp., 10 E. 40th St., New York
Samson	Pyroxylin film base	Do.
Sundora	Cellulose acetate	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J.
Sylphrap	Regenerated cellulosewrapping	Sylvania Industrial Corp., 122 E. 42 St., N.Y.C.
Cellophane Tec	Cellulose acetate	Tennessee Eastman Corp., Kingsport, Tenn.
Tego	Phenolic resin for plywood	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Templus	Phenolic molding compound	Bryant Electric Co., 1934 Weaver Ave., Bridgeport, Conn.
Vernonite	Methacrylate denture compound	Vernon Benschoff Co., 933 Ridge Ave., Pittsburgh, Pa.
Vinal	Vinyl acetal resin for safety glass	Carbide & Carbon Chemicals Corp., 30 E. 42nd St., New York
Vinylite X	Do.	Do.
Vinylseal	Vinyl sealing compound	Do.
Vistanex	Hydrocarbon resin	Advance Solvents & Chemical Corp., 245 Fifth Ave., New York
Vue-Pak	Acetate packaging material	Monsanto Chemical Co., Springfield, Mass.
Vulcoid	Phenolic laminated vulcanized fibre	Continental Diamond Fibre Co., Newark, Del.

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Beryllium Corp. of Pa., Reading, Pa.
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Brogan, Byard F., 805 Sansom St., Philadelphia, Pa.
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